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# SURGERY

*This book is dedicated to the*
*memory of the men from*
*St. Bartholomew's*
*who fell in the Great War*

# SURGERY

## A TEXT BOOK BY VARIOUS AUTHORS

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AND
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# PREFACE.

It is not possible at the present time to incorporate the whole of surgery in a single volume. Surgical anatomy, surgical pathology, clinical surgery, and the operative branches, now require separate treatises. The present volume is designed to supplement, but not to supplant, teaching at the bedside and clinical lectures, just as the best systematic lecturers used to teach the principles of surgery in such a manner as to lead their more intelligent students to interest themselves in the subject and to become desirous of advancing their art. The following pages will be found to deal with the practice rather than with the theory of surgery.

The divergence of views expressed by different writers often renders an otherwise excellent system of surgery unsuitable for the use of students. In this work an endeavour has been made to minimise the evil. The different articles have been allotted to members of a single large hospital where a daily exchange of ideas and a friendly spirit of mutual help in all difficult cases has long prevailed. It will be seen that the services of every member of the general surgical staff have been secured, whilst one member of each of the special departments has contributed an article on the subject in which he is especially interested. It is hoped that by these means a certain uniformity of opinion has been secured.

No special section has been devoted to military surgery, but an examination of the different articles will show that the subject has not been entirely neglected, and the results of recent experience have been incorporated in the proper places.

Many of the drawings for "Spencer and Gask's Surgery" ("Walsham's Surgery") were made from specimens in the St. Bartholomew's Hospital Museum, and, with the kind permission of the editor, Mr. W. G. Spencer, and of the publishers, Messrs. J. and A. Churchill, some of the blocks have been used to illustrate the present work.

We desire to acknowledge our indebtedness to Mr. A. L. Moreton, M.S., F.R.C.S., for carefully reading the proof sheets, as well as for much helpful criticism and many valuable suggestions. Mr. A. Kirkpatrick Maxwell and Mr. W. Thornton Shiells have placed us under an obligation for the excellent and painstaking manner in which they have carried out our instructions in connexion with the numerous fresh drawings which illustrate the book, whilst Messrs. J. and A. Churchill have extended to us their usual and well-known courtesy in everything that has pertained to its publication.

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# SURGERY.

## Section I.

### GENERAL SURGICAL PATHOLOGY AND BACTERIOLOGY.

#### Inflammation.

"INFLAMMATION is the succession of changes occurring in living tissues as the result of injury, provided that such is not so severe as immediately to destroy the structure and vitality of the tissue." This definition was put forward by Burdon Sanderson. The process is one of much complexity, and yet of common occurrence. In order to bring about the sequence of changes which are designated by the term "inflammation," three main factors are requisite, namely: (1) there must be an exciting cause, (2) which sets up a reaction by the tissues when so attacked, and (3) leads to certain effects which are the result of their antagonistic action.

Of the exciting causes trauma is amongst the commonest; infection due to micro-organisms known as bacteria, which frequently gain access to the tissues as the result of trauma, is also exceedingly common; in fact, these two form almost the only exciting causes of importance. The former may occur without the presence of the latter, but micro-organisms so often supplement the action of trauma as to become the most important factor in the process of inflammation.

The sequence of events occurring in the tissues of the body as the result of such an injury is known as "the reaction." The terminal effects of the process vary. The more severe the injury, or the more virulent the bacteria, the greater will be the effect on the tissues, and *vice versâ;* the better able the tissues are to withstand invasion, the more limited in extent will the inflammatory process be.

In those cases in which trauma apart from bacterial infection occurs the resultant effect is that of resolution; the tissues will return to their normal condition unless the initial injury is so severe as to give rise to permanent loss of tissue, under which circumstances deformities will be produced.

The more severe results of inflammation are as a rule seen after bacterial infection. It is true that in this case complete resolution may take place or, at the worst, fibrous tissue form as evidence of healing. Both of these are examples of the power of the tissues to withstand the effect of the bacterial poisons. On the other hand, the latter may possess the greater power and cause death of the tissues, such dead products being either gathered into a localised collection known as "*an abscess or localised suppuration*," or diffused throughout the tissues of the affected area, giving rise to a condition spoken of as "*diffuse suppuration.*" If suppuration occurs in one of the surface tissues of the body the covering epithelium may be shed and leave a raw surface—a wound so produced is called an *ulcer;* coincidently the tissues which surround the infected area may die as the result of an interference with

the blood supply of the part—this is called *necrosis* or *gangrene*. Even these conditions may remain strictly localised to the part affected and may heal by the formation of scars.

On the other hand, further changes of a more serious nature are liable to follow. Poisons excreted by the bacteria, known as *toxins*, may be liberated from the initial focus of injury and become absorbed into the general circulation, producing marked constitutional effects; the patient then is said to be suffering from *toxæmia*. Still further, the bacteria themselves may escape into the blood-stream and become distributed throughout the body, producing *septicæmia* (or *bacteriæmia*). Yet again, portions of infected tissues, especially blood-clot in the neighbouring vessels, may break off and be carried in a similar manner until they reach the smaller blood-vessels in some remote part of the body, through which the particles cannot pass; at such sites further abscesses will be formed, producing a condition known as *pyæmia*.

Toxæmia, septicæmia, and pyæmia are serious events in the process of inflammation, and frequently terminate the life of the patient.

Clinically the mode of onset serves as a means of defining two main types of inflammation. If the onset is rapid, the constitutional effect is marked, and there is a tendency for the various stages to be passed over in quick succession, the process is said to be *acute*. Sometimes the onset is insidious, considerable delay in healing occurs, or the more serious lesions may not become evident for a long time; then the process is said to be *chronic*.

Whichever of these types is present, the results above mentioned are equally liable to take place; in chronic suppurative lesions, however, a still further change is liable to occur, namely, *lardaceous degeneration* of certain organs.

The subsequent pages will deal with each of these conditions in detail.

## Causes of Inflammation.

The causes of inflammation may be grouped under two headings—1. Exciting causes; 2. Predisposing causes.

**Exciting causes.**—Two subdivisions are possible:—1. Those in which micro-organisms form the chief factor; 2. Those of non-microbic origin. It should be remembered that in this latter group, although the initial injury may be of traumatic origin and apart from the influence of micro-organisms, invasion by them is liable to occur at a later stage, a condition termed *secondary infection*.

1. **Microbic causes.**—The micro-organisms which are of primary importance in the production of inflammation are known as *bacteria;* certain of these are said to be non-pathogenic—that is, have a harmless effect on the tissues—while those having a harmful influence are said to be pathogenic. Many bacteria live normally in the human tissues as saprophytes without producing pathological lesions, *e.g.*, in the intestine. They cannot, however, be said to be non-pathogenic, for under suitable conditions they may bring about the inflammatory process. The majority of bacteria are, however, parasitic throughout their life history. They produce the inflammatory changes by virtue of certain poisons which they excrete either during their life or after death. These poisons or toxins vary in their chemical properties and the effect which they have on the living tissue.

Certain bacteria are known to be invariably responsible for the production of acute inflammations, whereas others are responsible for chronic conditions; some produce pus, for which reason they are said to be *pyogenic*, each bacterium is capable of producing a specific reaction. Moreover, the same micro-organism may have a different effect on two individuals, a point which

emphasises the statement that the main factors in the inflammatory changes occurring in human tissues as the result of bacterial infection are the virulence of the micro-organism and the powers of resistance which the affected tissues possess.

Bacteria or schizomycetes are unicellular plants, without chlorophyll, and may be divided into three groups :—

(i.) *Cocci or micrococci*, occurring as small round masses of protoplasm surrounded by a lining membrane. Arranged in pairs, they are called diplococci, in chains streptococci, and in groups staphylococci. They are non-motile for the most part, do not possess spores, and reproduce by fission ; in this group may be mentioned streptococci, staphylococci, pneumococci, gonococci, and meningococci.

(ii.) *Bacilli* occur as rods varying in length and occasionally form filaments known as streptothrix. Some possess flagella and have the power of motility; some reproduce wholly by fission, while others possess spores under certain conditions; this is of much importance in the consideration of the spread of disease for the reason that spores are extremely resistant to the effect of external agencies, *e.g.*, heat, chemicals, drying, etc., and will thus remain active in the sporing stage. In this group are B. diphtheriæ, coli, typhosus, and the bacilli of Gaertner, anthrax, tetanus, etc.

(iii.) *Spirilla* include bacteria having a spiral structure, *e.g.*, the vibrio of cholera, Vincent's spirillum.

(iv.) *Spirochætes*, for example in syphilis.

Most bacteria prefer to live under conditions where they have access to free oxygen, and are for this reason spoken of as *aerobes*. The majority of them will also grow, though not so well, in an atmosphere from which oxygen has been excluded ; these are known as *facultative anaerobes*, in contradistinction to those in whom life is impossible in the presence of free oxygen and are thus called *obligatory anaerobes*.

Bacteria enter the tissues by various routes ; the commonest mode of entry is directly through an open wound, a method of infection said to be of primary origin. At other times the origin of an infective lesion is endogenous, one of the bacteria having a normal saprophytic existence in the body suddenly taking on virulent functions and setting up an inflammatory process at a point which has been the site of an injury ; it is brought to this site by the blood-stream, and the lesion so produced is said to be of hæmatogenous origin. Presumably, in the normal condition of affairs, bacteria are to be found circulating from time to time in the blood-stream, and, unless some injury occurs, have no harmful effect.

The knowledge of the existence of bacteria in the body is taken advantage of by the surgeon, for he will not willingly undertake an operation on the patient until every possible source of infection has been removed. The effect of the action of a virulent bacterium is variable, depending largely on the natural powers of resistance of the tissues ; it may diminish owing to an acquired increase in these powers, and it is dependent on the formation of antibodies which act adversely on the bacterium ; the action of a micro-organism may be latent for a period owing to its encapsulation in some local focus, *e.g.*, lymphoid tissue, and be liable to give rise to recurrent attacks of inflammation under suitable circumstances, as, for example, during a period of lowered resistance on the part of the tissues.

2. **Non-microbic causes.**—These may be roughly classed under the heading of " Trauma " ; the primary injury is not due to bacterial infection, and the milder forms of inflammation only are seen. In many cases, however, micro-

organisms gain entrance to the injured tissues and are responsible for more serious lesions.

Exogenous non-microbic causes of inflammation include local injuries due to knocks, strains, etc., heat, cold, chemical agents, or foreign bodies, in contradistinction to those of endogenous origin, as exemplified by the presence of uric acid crystals in the tissues in a case of gout, new growths, and arterial degenerations.

Local injuries, such as a kick or severe tearing of tissues, lead to an extravasation of blood, which, acting as a foreign body, sets up a reaction on the part of the tissues; the same may be said of other foreign bodies, such as new growths and crystalline substances.

Heat and cold set up inflammatory changes by their action on the walls of the blood-vessels and cells of the tissues, thus liberating products of degeneration as irritative substances. Dead tissues so formed are extremely liable to become secondarily infected by bacteria. Chemical causes are exemplified most commonly by the toxins of bacteria; certain drugs, however, such as cantharides, turpentine, croton oil, especially when in contact with the cells of mucous membrane, are liable to cause their degeneration; strong antiseptics locally applied have a similar action.

**Predisposing causes.**—It is common knowledge that certain individuals are better able to resist infections than others; such a person is said to possess a *natural immunity*. This power of resistance is dependent on the existence of substances in the blood-stream and tissues of the body which are classified as antibodies; some of these substances neutralise the effect of the toxins of bacteria, and for this reason are alled *antitoxins;* others possess the property of killing the bacteria with which they come in contact and are known as *bacteriolysins* or antibacterial substances; yet again, there are the *opsonins*, whose object is to act on bacteria so as to render them more liable to ingestion by leucocytes; and further there are the *agglutinins*, substances which cause bacteria to collect into masses and lose their natural properties. The possession of these substances, and many others, constitutes the condition of natural immunity. It is a variable quantity even amongst individuals. When infection takes place the action of the toxins or the bacteria themselves is to bring these antibodies into action; or, if they are not present, to stimulate their formation, and thus produce an "*acquired immunity.*"

*It is the possession of natural immunity or the power of producing an acquired immunity which constitutes the resistance to infection.* Certain conditions are recognised in which there is an absence of, or a diminution in, the natural immunity to given infections; in these circumstances a person is said to have a *diathesis* and is recognised as being more liable to the infection. Any condition of anæmia renders a patient more liable to infection than when the blood conditions are normal. Diseases of the arterial or venous systems or of the heart itself, dependent on alcoholism, Bright's disease, diabetes, etc., render the tissues liable to the inflammatory process by diminishing the blood supply. Even certain nerve lesions have a similar effect.

**The inflammatory process.**—The following changes are observed as the result of injury by one of the causes above mentioned.

1. **The stage of hyperæmia.**—The first changes in inflammation occur in the blood-vessels and their contained blood. The arteries, veins, and capillaries all become dilated, in this way bringing a greater volume of blood to the part, rendering it relatively full of blood. Coincident with this there is a greater rate of flow of the blood-stream, and the corpuscles become arranged in a central or axial stream.

2. **The stage of stasis.**—Gradually the flow diminishes in its rapidity, a change first noted in the capillaries, then in the veins, and later in the arteries. This process does not take place instantaneously, but after a series of oscillations of the stream in a backward and forward manner. As the flow diminishes the white blood-cells leave the central stream and attach themselves to the walls of the vessel (*margination*) and to each other. Subsequently the red cells undergo a similar migration, forming themselves into rouleaux; eventually the stream completely stops. This is spoken of as *stasis*. The blood clots; the vessel wall loses its nutriment and dies, and at the same time death takes place of the tissues originally supplied by it.

3. **The stage of exudation.**—In normal healthy tissues there is occurring constantly an exudation of fluid constituents from within the vessel into the surrounding tissues, bringing to them the food products which they require. In the inflammatory process this exudation is increased in the area of injury, often to such an extent as to make the parts succulent and swollen. It consists of almost pure blood serum, and in the early stages does not contain either leucocytes or red blood cells. It carries with it the antibodies, whose business it is to act antagonistically to the infecting agent. Besides being derived from the blood serum, it is thought that part of the exudation is the product of the endothelial cells which take on a secretory function.

4. **The stage of migration.**—Very early in the inflammatory process the white blood cells, which adhere to the vessel wall, make their way through it between the cells, together with the serum, into the surrounding tissues and progress towards the focus of injury; in more severe injuries these cells migrate in very large numbers; this process is spoken of as *diapedesis*. In a very severe type of inflammation the red cells will also be discharged into the tissues, and should the blood-vessel wall die or rupture, considerable infiltration will occur.

There are certain terms in connection with these changes occurring in. blood-vessels which require to be mentioned. A clot of blood in the vessel following stasis is known as a *thrombus*. The swelling produced as the result of exudation, should it occur in a deep-set tissue, is known as *œdema*, whereas if it takes place under or amongst the superficial epithelial cells it produces a *blister*. When the exudation takes place on to the surface of a tissue it is inclined to clot, depositing fibrin and producing a false membrane commonly spoken of as *lymph*.

5. The next changes occur in the tissues into which the exudation has taken place, including the fibrous tissues of the body, connective tissue cells, epithelial cells, etc. The first change in them is also in the direction of destruction. The connective tissue fibres become swollen and break up, partly as the result of absorption of the fluid exuded from the blood-vessels and partly from the action of the leucocytes. The connective tissue cells proliferate and act in a manner similar to that regarded as the function of the leucocyte; possibly their destruction produces some of the antibodies already mentioned in addition to those brought by the blood-stream. Their function, although to a certain degree antagonistic to the infecting agent, is, however, more concerned with the reproduction of new tissue and with the process of healing, an observed fact which is upheld by the predominant numbers of polymorpho-nuclear leucocytes derived from the blood-stream in acute inflammations as compared with the more numerous connective tissue cells seen in the milder forms of chronic inflammatory processes. The terminal results of the process are dependent on the virulence of the infecting agent and the resistance put up by the tissues. Complete resolution, the formation

of fibrous tissue, suppuration, and the dissemination of infection by the blood-stream are all liable to follow and are changes which must now be discussed.

**The process of regeneration.**—When stabilisation has been reached between the invasion of the irritant and the reaction on the part of the tissues and the blood, many constituents taking part in the inflammatory process will be found to be present, namely, blood serum, leucocytes, red blood cells, endothelial cells derived from the vessel walls, and cells derived from the connective tissue of the part; moreover, there is considerable increase in the vascularity. This new tissue is known as *granulation tissue*. The cells have all been brought to the site of injury as the result of the invasion of the micro-organism, which will be found lying amongst and in the cell elements. For regeneration to occur each has its own particular function to perform: chemiotaxis, phagocytosis, the liberation of antibodies, and the destruction of the tissues into such elements as to render their products capable of absorption.

1. **Chemiotaxis.**—During the early stages of the inflammatory process the leucocytes, especially those of the polymorpho-nuclear type, together with certain of the fixed cells of the tissue, tend to migrate towards the focus of injury. It is thought that this is due to a certain attraction which the micro-organisms, or their toxins, have the power of exerting. This property is spoken of as *chemiotaxis*, and the attraction of the cells as *positive chemiotaxis;* the opposite effect, namely that of repulsion, presumably due to the intensity of the virulence of the toxin, is *negative chemiotaxis;* there is some doubt as to whether the latter phenomenon ever occurs.

2. **Phagocytosis.**—One of the most important functions exhibited by the cells in the process of resistance to bacterial infections is the property which they possess of taking into their substance micro-organisms, cell débris, pigments, or even whole cells. This property is spoken of as *phagocytosis*. The cells which possess this power may be divided into two main groups—those derived from the blood-stream and known as *microphages*, and those derived from the fixed tissues, called *macrophages*. The micro-organisms or débris taken up by cells possessing this property rapidly lose their staining properties and eventually disappear, owing to the digestive action of a ferment contained in the cells. The cells often die as the result of this process, in turn forming débris liable to phagocytosis. This does not necessarily happen, for they may survive and still serve a useful function in the reproduction of fresh tissues if they are macrophages, or carry their contents into the lymph glands if they are microphages. The result of the death of the cell is the liberation of toxins and certain antibacterial substances which it has absorbed, products which destroy other micro-organisms which have not already been "phagocyted," or are added to the supply of these substances in the blood-stream. It is also thought that they are responsible for the liberation of antibodies, called by Wright *opsonins*, which have the effect of acting on the bacteria in a manner rendering them liable to phagocytosis by the leucocytes. The ferment liberated from the cell, if sufficient be left after digesting its captives, may still act by destroying and liquefying cell débris, thus rendering the latter easily absorbable. This process is known as *proteolysis*. In this way most of the products of the inflammatory process are rendered capable of assimilation; such actually occurs, leaving behind only those factors whose property it is (1) to restore completely the tissues to their normal state; (2) to produce a healthy scar.

The fixed tissue cells, *i.e.*, the endothelial cells of the blood and lymphatic

vessels, and the connective tissue cells, are observed to proliferate by cell division very shortly after the beginning of the inflammatory process; in the more severe types of inflammation this is less marked than in the milder forms; in the former hardly any proliferation is seen, whereas in the latter the reaction of the fixed tissues is more evident than the reproduction and migration of the phagocyting cells. In the chronic types of inflammation the two processes are carried on to an almost equal extent.

The cells elongate and form fibres which eventually fuse together to form fibrous tissue; for this reason they are spoken of as *fibroblasts*. In the case of an ulcer where the granulation tissue lies exposed on a body surface, the surrounding epithelial cells grow over the underlying fibrous tissue from the edges of the ulcer towards its centre, until complete regeneration has occurred. The amount of fibrous tissue formed will be dependent on the degree of destruction resulting from the injury. If the inflammatory process is so slight that the amount of fibrous tissue produced is extremely small, or even wanting, complete resolution will occur.

In the early stages of the inflammatory process it has been mentioned that the circulation of the part is interfered with by the formation of a thrombus within the walls of the blood-vessel; coincident with the changes mentioned above fresh blood-vessels are formed by the proliferation and extrusion of the endothelial cells into the tissues and even into the blood-clot itself. These cells form tubes with a central lumen, thus producing a new vessel from the capillaries. By means of this newly-formed vascular system the fluid products of inflammation are taken up into the capillaries and thence by the veins into the general circulation. Broken-down cells, leucocytes and their "phagocyted" contents, even the bacteria themselves, are carried off by the lymph *viâ* the lymphatic vessels into the lymph glands, where they are destroyed. In lymphatic glands examined at this stage these substances can be observed; moreover, live micro-organisms can be demonstrated in them by bacteriological methods. This is an important clinical fact, because the lymphatic gland so infected may not be sufficiently resistant to the action of the micro-organisms, and they or their products may be carried off to some other part of the body; thus the absorption of these substances through the serous exudate into the lymphatic or vascular systems may not be altogether a desirable result. As an alternative the exudate may become coagulated and form a fibrinous false membrane entangling in its meshes the leucocytes and micro-organisms; this may be desirable, but at the same time the net result is always to form fibrous tissue in excess of that which is required. The harmful effects of the absorption of these products of inflammation by the tissues will be dealt with at a later stage.

**The process of suppuration.**—In the inflammatory process already described the effect has been to bring about a reproduction of normal or healing tissues. In the presence of active pyogenic micro-organisms the result may not be so satisfactory; the virulence of the micro-organism may be so far in excess of the powers of resistance of the tissues that the latter may be destroyed: the leucocytes, the connective tissue cells, and the tissues generally may degenerate excessively, and only when the process of regeneration is able to obtain the upper hand is such likely to come to an end; this is the process of suppuration. It is more likely to occur with certain micro-organisms than others, namely those of the pyogenic variety. Suppuration, although usually depending upon infection with micro-organisms, may result from the injection into the tissues of such substances as dead micro-organisms, as in the case of a vaccine, and certain drugs, *e.g.*, silver nitrate or mercury. It must be noted.

however, that suppuration of this latter type behaves quite differently from that of microbic origin, for it tends always to remain localised, does not disseminate into the surrounding tissues, and does not have a harmful effect when inoculated into other animals.

On observing the minute details of the process of suppuration the following changes are seen to occur :—Up to the stage of migration of leucocytes with a dilatation of the blood-vessels around the part, and the exudation of serum, the process of inflammation already described takes place ; the vascular dilatation, however, is more marked ; the exudation of serum into the tissues is very considerable ; the cells of the blood-stream become extravasated in such numbers as almost to fill the field of action, those most predominant being polymorpho-nuclear leucocytes ; the connective tissue cells do not take such an active part as in the milder forms of inflammation—in fact, they are difficult to find. The process of degeneration is in excess, and that of regeneration, for the time being, is in abeyance. The micro-organisms multiply in the tissues and are not " phagocyted " to the same degree.

The tissues in which the extravasation occurs die and become swollen by exudate which coagulates into fibrin, a process termed *coagulation necrosis*. Later large numbers of micro-organisms are found in the leucocytes. The tissues liquefy in a similar manner to that already described, so that the centre of the area of infection becomes quite fluid and contains in it the dead leucocytes and connective tissue cells ; this fluid is spoken of as *pus*, the dead cells being known as *pus cells ;* surrounding these are dying cells, and still further out those which are waging war with the bacteria. Eventually an equilibrium is reached and a zone is found in which proliferation and regeneration show signs of getting the upper hand, and even at the outermost zone fibrous tissue may have already formed from pre-existing vascular granulation tissue, especially in the more chronic types of suppuration. Running in these zones are blood-vessels which often contain thrombi. As soon as the tissues of the body gain the upper hand fibroblastic reproduction takes place, and the process of suppuration terminates. Such a localised collection of pus is spoken of as an *abscess*.

Localised suppurations may be divided into two groups—the acute and chronic abscesses. As exciting causes of the former group the pyogenic bacteria are most commonly found, although they may also produce the chronic type. The tubercle bacillus and actinomyces are most commonly responsible for chronic abscesses. If a chronic abscess is due to pyogenic bacteria it will frequently be found that, at the time of investigation, the micro-organisms are already dead. The distinction from an acute abscess depends upon the more insidious onset, the more definite localisation of the pus by a dense fibrous wall, and its liability to become completely encapsuled and remain in a latent condition for a considerable length of time. Occasionally the purulent material may become absorbed and the cavity replaced by fibrous tissue.

An abscess may rupture into the surrounding cellular tissue or some important structure, *e.g.*, a joint or the peritoneum, or if it lies close to the surface of the body it may burst externally, leaving a small track lined by granulation tissue, called a *sinus*. Infection of the general blood-stream through localised thrombi in the vessels around the cavity may follow, these being discharged into other parts of the body as foci for metastatic abscess formation.

Besides the formation of an abscess another type of suppuration may be met with. It may be either primary in origin or secondary to a localised suppurative process, and may be caused by infection with any of the pyogenic

bacteria, but is more often associated with the streptococcus group. It is a condition in which the connective tissue elements cannot resist to any extent the invading micro-organisms, the leucocytes being left to deal with them to the best of their ability. The micro-organisms multiply in large numbers, resulting in the production of inflammation along the course of the lymphatic channels. This type of inflammation often goes on to suppuration and is most likely to occur in the loose connective tissues which underlie the skin and mucous membranes or in the organs of the body; it is termed *cellulitis* or *diffuse suppuration*. In this condition invasion of bacteria into the blood-stream is very liable to take place, no definite fibrous tissue wall being formed, as in the case of an abscess.

Yet again, suppuration may result from an acute inflammation of either mucous or serous membranes. Examples of the former are seen in the bladder, the alimentary tract, the nasal sinuses, etc., and of the latter in the peritoneum, pleura and pericardium, and joints. The process of pus formation is essentially the same as in the case of localised and diffuse suppuration in other positions, except that the products are exuded and collect in the cavity lined by the membrane affected. In connection with suppuration of the mucous membranes, a considerable amount of mucus is produced, probably as a result of degeneration of desquamated epithelium or possibly derived from goblet cells in the membrane. This type is extremely prone to pass on to ulceration.

In sero-purulent inflammatory processes fibrin becomes deposited in the cavity and tends to localise the spread of the inflammation, though not always with success; thus a portion only of the cavity may be involved.

**The characters of pus.**—The fluid contents of a suppurating area is known as *pus*, which contains pus corpuscles, granular material, micro-organisms, blood serum derived from the vessels with its contained antibodies, and dead connective tissue fibres. It is typically a thick, creamy, opaque, yellowish-white, alkaline fluid, salt in taste, varying in odour, with specific gravity about 1,030. Most of the pus cells are dead, swollen and degenerate, containing vacuoles and fat granules. In an acute abscess some of the live cells may still be found showing their characteristic amœboid motions when examined under suitable conditions. The fluid constituent of pus coagulates on boiling, and contains albumen with certain salts, especially sodium chloride. It does not coagulate instantaneously, as the fibrinogen has already formed fibrin. The micro-organisms which are to be found in the pus include most commonly the staphylococcus, streptococcus, gonococcus, pneumococcus, bacillus coli or bacillus pyocyaneus; sometimes the tubercle bacillus, actinomyces, and anäerobic bacilli may be present. When pus is found in connection with a mucous surface there is often an admixture of mucus with the purulent material, giving it a thicker and ropy consistency. This is spoken of as *muco-pus*. In serous cavities lymph is excreted in excess, and fibrin becomes deposited in the purulent material. This is termed *sero-pus*.

**Ulceration.**—Ulceration is the condition which is liable to follow an injury to a surface tissue of the body. It commences in the submucous or subcutaneous tissues as a process similar to that occurring in the other types of inflammation. In this case the inflammatory exudate, often with abscess formation, takes place into the tissues, the epithelial layers being raised above the surface. Sometimes the exudate passes between the epithelial cells, producing small blisters known as *vesicles*. Into this exudate the leucocytes are then poured, and they produce small localised collections of pus, spoken of as *pustules*. In the course of time the whole of the surface epithelium is raised, the exudate is discharged on to the surface, and the

layer of granulation tissue comes to lie on the surface ; this process is spoken of as *ulceration*, and the area left exposed is termed an *ulcer*. An ulcer may be formed by the bursting of a large abscess which, having discharged its pus, virtually becomes an ulcer.

**Healing of suppurative processes.**—The healing of an abscess cavity and the healing of an ulcer have many points in common. They each of them have surrounding areas of fibrous tissue, and are lined by granulation tissue. In the case of an abscess, the pus having been discharged, the surfaces of granulation tissue fall together, commencing at the point of greatest pressure, namely, at the most distal end. The fibroblasts grow from side to side and, eventually working from the base upwards, occlude the space which originally existed. This, however, does not always occur, for, instead of falling together, the walls, of the abscess cavity, on account of their rigidity, may remain apart, as in the case of a bone abscess or one of long standing, a dense fibrous ring having formed outside its lumen. Under these circumstances the granulations have to proliferate until they themselves can join and heal in the manner already indicated. This method of healing also occurs in the case of ulceration, the fibroblasts forming at the base many layers of fibrous tissue until the whole of the granulation tissue has become converted into a scar, over the surface of which the epithelium at the edges of the ulcer grows in order to bring about as nearly as possible a normal resolution. This is spoken of as *healing by second intention.*

**The processes of dissemination.**—When a micro-organism enters the human tissues it does not necessarily produce an obvious local inflammatory condition, but may be carried directly into the blood-stream. As a rule, however, there is at the site of its introduction a lesion, which may be in the form of either a pustule, cellulitis, an abscess cavity, or even an ulcer. The tissues around are very vascular ; a reproduction of resisting agents, including the leucocytes, the connective tissue cells, and the antibodies, is constantly occurring. An absorption of certain products of degeneration both by the lymphatic vessels and the blood capillaries is also taking place ; the more fluid constituents are taken by the latter, the more solid, *viâ* the phagocytes, by the former to the lymphatic glands. It is the absorption of these products of degeneration which brings about the constitutional disturbances which are observed in cases of inflammation. Those which are harmful to the human body are known as toxins, and bring about a condition spoken of as *toxæmia ;* macroscopically, and even microscopically, there may be no evidence in the tissues of the body of any inflammatory change under these circumstances ; usually, however, the cellular elements show evidence of congestion and even degeneration.

During the inflammatory process a certain number of living micro-organisms obtain access to the blood-vessels around the area of infection. Here they are killed by the leucocytes and the antibodies, and their toxins are diluted to such an extent as not to bring about any serious disturbance. Possibly there may be some advantage in the absorption of these, as the toxins are carried to some healthy tissue which is capable of reproducing fresh antibodies and thus aiding in the production of an acquired immunity. This process is kept up without serious effect until such a time as the influx of micro-organisms is too great for the tissues to resist—*i.e.*, the war between the micro-organisms and the resisting tissues will be in favour of the former so that they are found in large numbers in the circulating blood-stream ; this process is described as *septicæmia* or *bacteriæmia*. The resultant effect of this excessive migration of bacteria will be that their toxins will produce inflammatory changes of a

particular type in most of the tissues of the body, especially in the serous membranes and epithelial structures of the viscera, the former being manifest by the appearance of petechial hæmorrhages and the latter by a destruction of the cell substance by a fatty degeneration. An enlargement of the spleen is also frequently seen in this condition. Micro-organisms can be demonstrated both during and after death in the blood and the organs.

The condition known as *pyæmia* may be due to infection by any micro-organism, but is most commonly associated with staphylococci and streptococci. It has already been mentioned that the blood in the vessels around an inflammatory area becomes clotted in the form of a thrombus which obstructs the lumen of such vessels. In the more acute types of infection this clot is liable to become invaded with micro-organisms; this leads to the destruction of the clot with an inflammatory reaction around it, an abscess formation, and in some cases may even so act on the endothelial cells of the capillaries as to bring about the rupture of the vessel. Pieces of this clot may break off and be carried into the circulation; such are spoken of as *emboli*. They eventually arrive at some other part of the body where the capillaries are too small to allow of their passage; they cause a blockage and lead to the formation of fresh localised abscesses. These are pyæmic or metastatic abscesses, and the production of many such constitutes the condition known as *pyæmia*. These abscesses are most commonly found in the lungs, spleen, kidneys, brain and joints, but may be found in any part of the body. Secondary involvement of tissues in their neighbourhood is extremely liable to occur.

**Clinical evidence of acute inflammation.**—Clinically, all diseases produce two groups of symptoms—(1) those dependent on the lesion at the initial site of the disease and (2) the equally important constitutional effects. In no condition is this more true than in inflammation.

*Local signs and symptoms of inflammation.*—The evidence of inflammation is, generally speaking, the same in whatever structure of the body it occurs. The signs are more easily recognised, however, when the inflamed area is near to the surface of the body than when deeply situated. The evidence depends on the presence of some or all of the five following signs: *pain, heat, redness, swelling, and diminution of function.*

The *pain* felt by the patient is due to the congestion of the parts as the result of dilatation of the blood-vessels, and also to the effect which the pathological exudate has on the sensory nerve endings; it varies considerably in character. In the early stages there is a feeling of fulness and throbbing; later it will be found to vary with the degree of exudation and the amount of stretching which is possible in the tissues involved; for example, the pain is less severe in a case of inflammation of the subcutaneous tissues than when situated in the centre of a bone cavity. A familiar instance of the latter is the pain caused by inflammation in a tooth socket.

*Heat.*—An increase in the temperature of the tissues at the site of injury is due to the dilatation of the blood-vessels. This is perhaps one of the most important signs of inflammation, for whereas many of the others may be absent, this, upon careful observation, can usually be detected; the more acute the process the more obvious will be this sign; the nearer to the surface the inflamed structure is the more easily will it be felt; it is a sign which can not only be made out by physical examination, but is often complained of by the patient.

*Redness.*—Redness, when present, is exceedingly important evidence of the condition. Again, dependent upon the dilatation of the blood-vessels, it is

obviously best seen in surface structures—for example, skin or mucous membrane : again, the more vascular a part is normally the more readily will it be recognised ; it will vary from a faint blush to an intense rose-red or purple colour, dependent on the degree of stasis in the vessels : moreover, it is most marked at the most inflamed portion of the affected area, and gradually fades at the margins into the colour of the normal tissues.

*Swelling.*—The swelling is the result of the exudation. One of the characteristics of this swelling is that when pressure is made upon it firmly by the finger for a few seconds, it will be found to have produced a pit which fills up a gain quite slowly. The recognition of œdema in this way is often the only sign which leads to the diagnosis of inflammation in deeply-situated organs, but it is also present in most of the superficial inflammatory processes. In mucous membranes it is often a very noticeable feature.

*Loss of function.*—This is almost invariably present—for example, the skin will become dry ; the mucous membranes show a diminution in their secretion ; pain causes joints to become temporarily fixed by virtue of spasm of their controlling muscles. Similar evidence of involvement of other lining membranes is also characteristic ; in the case of such organs as the kidney the function is limited very considerably. In later stages of mucous membrane inflammations the secretions are markedly increased, the mucus becoming mixed with the exudation.

*General symptoms of inflammation.*—These include (1) fever, and (2) the coincident effects of fever.

*Fever* is a sign of primary importance. It is dependent on the absorption of toxins derived from bacteria or from the products of destruction of tissues resulting from the inflammatory process at the site of the local lesion. The type of fever varies considerably. The mode of onset is often significant ; a sudden rise of temperature, accompanied by a feeling of chilliness, or even shivering, is spoken of as a *rigor ;* this is followed after a period of five minutes to an hour by a sudden fall of temperature associated with profuse sweating. It is usually indicative of a severe form of infection. In non-infective processes, those associated with trauma, a slight rise of temperature, usually lasting for a few hours, is commonly seen and is known as *aseptic traumatic fever*, in contradistinction to the type called *infective fever*, which persists so long as bacteria remain in a lesion.

Fever points to an excess of heat being produced as the result of increased oxidation, as demonstrated by the greater amount of urea and other nitrogenous substances excreted in the urine, by the rise of the amount of carbonic acid expired, by the loss of body weight and the using up of fat. Early in fever, when the vessels are constricted and the skin is pale, there may be no loss of heat above the normal, even less ; but at the height of the fever, when the skin is hot, there is an increased loss, but not proportionate to the increased production.

The rigor is the result of the contraction of peripheral vessels so that the amount of heat reaching the skin is less than normal : this sets up a reflex involuntary contraction of muscles ; later the skin becomes hot, and sweating occurs as the result of vaso-dilatation.

The second sequence of events coincident with fever includes a diminution of all the secretions of the body ; the skin becomes dry owing to vaso-constriction, although excessive secretion may be observed when the temperature falls. These conditions may alternate especially at night-time, producing a type spoken of as *hectic fever*. All the glandular tissues of the body show a diminution in their secretions ; the mouth and lips become dry owing to a

deficiency in saliva, and consequently the patient complains of thirst; cell débris causes the tongue to become coated with fur; the gastric juice is diminished in amount, loss of appetite (anorexia) resulting, and even should the patient take food, it cannot be digested; similarly the secretions of the intestine are diminished, causing constipation; the kidneys also participate in this loss of function, the urine being small in amount, concentrated, and possessing an excess of nitrogenous excreta. The other general constitutional disturbances include an increase in the frequency of the pulse, which in well-nourished persons is full and bounding; a lessening in the pulse tension as the result of the effects of the toxins on the heart muscle is observed in severe or prolonged infections, especially in weakly individuals; it is ofttimes responsible for the death of the patient. The blood cells suffer with the production of a secondary anæmia and an increase in the number of leucocytes. The muscle tissues of the body become weakened, and the nervous system is similarly involved—malaise, headache, delirium, all have their place under this heading.

*Resolution.*—The clinical evidence of recovery is gauged locally, first by a disappearance of the pain and redness, followed later by the loss of heat and œdema, and secondly by return of function of the affected part. The temperature gradually falls to normal, and the other coincident symptoms likewise abate.

**Other methods of observation.**—It is extremely important always to take steps to define the actual cause and site of the inflammatory process Often the history of the condition will contain sufficient information on this point, *e.g.*, injury by heat in the form of hot water, the burning of the skin as the result of fire, or the taking of corrosive acids and their resultant effect upon the mucous membrane.

Superficial signs of inflammation do not necessarily mean that the initial focus is at the surface; it may be that one of the deep organs is primarily affected, and that the former has only become secondarily involved as a result of the spread of the exudate. A good example of this is the case of an infection of the tendon sheath of one of the fingers; the tendon sheath first becomes involved, and the inflammation on the surface is not marked; subsequently the skin becomes red, hot, painful and tender, but at that stage it is difficult to locate the site of the initial focus. From the point of view of prognosis and also of treatment it is obvious that the recognition of the primary site of the lesion is of great importance, and careful observation alone can define it.

If bacteria are present, an attempt should always be made to demonstrate the type of micro-organism. In certain conditions it is obvious that the inflammatory process is due to a particular micro-organism on account of the characteristic appearance of the lesion; conditions such as furunculosis, cutaneous anthrax, and malignant œdema may all be recognised by clinical observation as being due to specific agents. On the other hand, it may be necessary to call in the aid of the bacteriologist to clinch the diagnosis by special methods of investigation. This should never be omitted even in the mildest types of infection, for from the points of view of both prognosis and treatment it is essential that this knowledge should be obtained and clinical appearances alone should not be relied on.

Having defined these points, an attempt should be made to estimate the extent of the spread of the inflammation, not only as regards the neighbouring tissues, but also the blood vascular and lymphatic systems.

A clinical observation of the whole of the body tissues must be gone into.

Such investigations as blood cultivations are called for in the more severe infective processes. The degree of resistance which the patient is able to put forward must also be investigated; for example, the enumeration of the leucocytes and the estimation of antibodies.

## Methods of Examination of Blood; and Findings.

**Examination of the blood.**—It is not proposed to enter into a detailed account of the methods of carrying out the various technical procedures, but to point out the various investigations which are of service in making a clinical diagnosis in a surgical case.

The examinations possible include the enumeration of the red and white blood cells, the percentage of hæmoglobin, the presence or absence of micro-organisms by blood cultivation, the agglutinin reaction, the estimation of the opsonic index, and the complement fixation test.

*The red blood cells.*—Normally there are 5,000,000 cells per cubic millimetre of blood. After a sudden hæmorrhage or prolonged illness, especially if associated with fever or wasting, *e.g.*, infections, malignant growths, etc., there is a diminution in this number (oligocythæmia). Alterations in shape (poikilocytosis) occur in pernicious anæmia. Nucleated red cells are seen under the same circumstances.

*Hæmoglobin.*—This may diminish or increase proportionately with the red blood cells; in most anæmias there is a loss of hæmoglobin out of proportion to the cells, especially during the stage of recovery, when the latter return to their normal more speedily than does the hæmoglobin. It is inadvisable to anæsthetise a patient whose hæmoglobin percentage is below 30. Successful operations, however, have been performed with a much smaller amount. In certain conditions the hæmoglobin becomes dissolved out of the cells, and mixes with the serum, and even appears in the urine, two conditions respectively termed hæmoglobinæmia and hæmoglobinuria. Raynaud's disease, acute fever, sepsis, frost-bites and burns are the commoner conditions in which this is found.

*Leucocytes, or white blood cells.*—The normal number of white blood cells per cubic millimetre of blood is 5,000 to 10,000. An increase in the number of cells is spoken of as a *leucocytosis*, in contradistinction to *leucopænia*, which is the term applied to a diminution in them.

The leucocytes are divided into the following groups and numbers:—

| | Percentage. | Absolute number per cubic millimetre. |
|---|---|---|
| Polymorpho-nuclear leucocytes .. | 60—75 | 3,000—7,500 |
| Large mononuclear leucocytes .. | 4—8 | 200—800 |
| Lymphocytes .. .. .. | 20—30 | 1,000—3,000 |
| Eosinophiles .. .. .. | 0·5—5 | 25—500 |
| Basophiles .. .. .. .. | 0·5 | 25 |

Abnormal cells, *e.g.*, myelocytes, occur in certain pathological conditions.

Leucocytosis may be either physiological or pathological, the former being seen in infancy, during digestion, in pregnancy, after exercise and various thermal variations.

**Pathological leucocytosis.**—Clinically various types of leucocytosis may be recognised: 1. Inflammatory; 2. Post-hæmorrhagic; 3. Due to malignant disease; 4. Toxic; 5. Due to blood diseases.

1. *Inflammatory leucocytosis.*—This is seen in most infective conditions, especially those of pyogenic origin, syphilis, acute rheumatism and scarlatina.

In typhoid fever, measles, Malta fever, and mumps it is wanting. The increase in the number of leucocytes varies from 10,000 to 30,000 per cubic millimetre, and is especially seen in connection with the polymorpho-nuclear cells, a point to be noted in distinguishing infective conditions from those of blood cell diseases. In using the leucocyte count as a means of diagnosis, the following points should be noted :—

(1) Several observations at intervals are essential, although a single enumeration may be suggestive.

(2) The result must be considered in conjunction with the other clinical signs, and not by itself.

(3) Differential cell counts are always desirable.

Interpretation of results :—

(1) In cases of infection a low leucocytosis may mean (*a*) that the infection is a mild one ; (*b*) that the infection is severe and the tissues are unable to put up a reaction ; (*c*) the inflammation may have become localised, and toxic absorption is not taking place.

(2) The presence of a leucocytosis excludes conditions in which it is known that a leucopænia typically occurs ; especially is this useful surgically in distinguishing typhoid fever.

(3) In cases of localised infection a high polymorpho-nuclear leucocytosis is suggestive of the presence of pus ; this is taken advantage of in the diagnosis of appendix abscesses. The numbers frequently rise to 20,000 to 30,000 per cubic millimetre. A gradual increase during the course of the disease is of prime importance in indicating the desirability of exploration. Numbers below 20,000 suggest acute infections prior to pus formation.

(4) In acute perforative intestinal conditions the leucocytes increase in number almost immediately, a point to be borne in mind in the case of perforation of typhoid ulcers.

2. *Post-hæmorrhagic leucocytosis.*—After a sudden severe hæmorrhage there is a considerable leucocytosis (16,000—20,000). This does not occur after repeated small hæmorrhages.

3. *Leucocytosis in malignant disease.*—The chief changes in the blood during malignant disease are those of a secondary anæmia, diminution both in the number of red cells and in the amount of hæmoglobin. Associated with these in the later stages of the disease there is a moderate leucocytosis, usually of the polymorphonuclear type. It is probably dependent on the bacterial infection so commonly connected with these conditions.

4. *Toxic leucocytosis.*—Such conditions as chloroform narcosis, quinine poisoning, acute yellow atrophy, vaccine injections, intravenous normal saline injections, and anæmia give rise to a leucocytosis.

5. *Blood diseases with leucocytosis.*—Lymphocytic leukæmia, myelogenic leukæmia.

**Leucopænia.**—A physiological form of leucopænia occurs after prolonged exposure to cold and starvation. Pathologically the commonest condition with which it is associated is typhoid fever, the numbers often falling as low as 2,000 per cubic millimetre. Paratyphoid fever, tuberculosis, splenic anæmia and lymphadenoma are other conditions likely to be met with by surgeons in which there is no increase in the numbers of leucocytes, but in which they may even be diminished.

**Examination for micro-organisms.**—The finding of micro-organisms in the blood-stream is only possible by obtaining considerable quantities of blood ; 5—10 c.c. at least must be extracted from a vein, preferably the median basilic or median cephalic at the bend of the elbow. Many film

preparations of this should be made, and occasionally micro-organisms can be demonstrated. Quantitative cultivations varying from a single drop to 2 c.c. should also be made. A negative result in this method is worthless, but a positive finding is of considerable value in defining both the exact diagnosis and extent of an infective process. Its prognostic value is almost negligible, for it is frequently found that micro-organisms will fail to grow in the advanced stages of bacteriæmia and pyæmia and are sometimes found in the earliest stages; still even from this point of view its significance must not be wholly neglected.

**Agglutination test.**—The only agglutinin reaction in common use is for purposes of diagnosis in cases of typhoid fever (Widal's reaction). The reaction does not come off until the end of the first week; blood cultivation is therefore preferable in this condition, as the bacillus can be recognised by this means during the first forty-eight hours. In surgery it is most commonly applied in distinguishing typhoid bacilli from other members of the coliform group in similar lesions, the micro-organism being agglutinated by a known typhoid serum.

**Opsonic index.**—The opsonic index is very seldom made use of either for purposes of diagnosis or treatment. It is occasionally used in defining a micro-organism in a case of infection when other bacteriological investigations have failed; it is also used in observing the progress of tuberculous infections both during their normal course and also during the treatment by tuberculin.

**Complement fixation test.**—This is most frequently used in the diagnosis of syphilitic conditions and is of considerable value. The method has also been applied to the differentiation of other lesions, notably hydatid cysts and obscure gonorrhœal infections.

**Clinical evidence of chronic inflammation.**—The clinical differentiation between acute and chronic inflammation is one of degree only. The onset of a chronic inflammatory process is usually insidious, although it may result from the acute type. Owing to a lesser degree of vascularisation of the tissues, to a smaller exudation of blood cells, and a greater effort at repair, the heat, redness and swelling, although present, are less obvious; loss of function is always to be found, usually owing to the resultant formation of fibrous tissue; pain may be absent.

The constitutional disturbance, unless the process is due to specific bacteria, *e.g.*, tubercle, is much less marked than in the acute inflammatory processes.

The termination of chronic inflammation is either suppuration or fibrosis.

**The treatment of acute inflammation.**—No one given method of treatment is applicable to all cases; that which may be the correct treatment for the early stages of an inflammatory process may be quite incorrect for such conditions as follow afterwards. It has been intimated already that a knowledge of the causal factor and the exact extent of the involvement of tissues is requisite before any efforts are made to deal with the condition.

Where foreign bodies, carious teeth, or sequestra are found, it is the duty of the surgeon to deal with these before any further methods of treatment are adopted. In the case of microbic infection it is seldom possible to eradicate the micro-organisms completely, but an attempt should be made to limit the extension of an inflammatory process; though it is not necessarily dangerous, it is liable to become so. The terminations already described may cause such loss of function to the tissue involved, should the process be allowed to progress, as to be an inconvenience and even a permanent injury to the patient.

*Operative procedures.*—Operative measures are not often requisite in cases

of acute inflammation of non-microbic origin; they are applicable to lesions of microbic infection, especially to those in which it is known that the bacterial agent is one of considerable virulence and liable to produce grave sequelæ.

Amongst the first group may be mentioned the removal of blood-clot or other foreign bodies, *e.g.* bullets, tooth-plates, fish-bones, which frequently demand surgical interference.

Of the second group three types of case demand good judgment and skilful treatment. Firstly, there is a type of microbic infection which frequently subsides if allowed to run a natural course aided by palliative measures, *e g.*, erysipelas, furunculosis, ulcerative stomatitis, and acute arthritis, etc.; but if subsidence does not occur, or there is a tendency towards involvement of considerable areas of tissue, incision or excision may be called for. The second type includes lesions which are known to lead to fatal results, which speedily disseminate to lymphatic glands and the blood vascular system, or which at the time of observation have already spread in this manner; such conditions as acute infections of the uterus, post-mortem room wounds, streptococcal infections of subcutaneous tissue or tendon sheaths and lateral sinus thrombosis are examples of this group, which demand urgent surgical measures in the early stages. The third type includes those cases in which an acute or subacute inflammation of a tissue or tissues is dependent on what may be a comparatively trivial infection of a distant part of the body. Gonorrhœal arthritis and other forms of infective arthritis often call for attention to the primary foci—*e.g.*, prostate, teeth, etc.—by surgical methods before the local condition complained of by the patient can be relieved.

In the acute stages of an inflammatory process, especially those in which an infecting micro-organism is not present (hence the less dangerous types of the disease), the initial form of treatment consists in dealing with the symptoms from which the patient is suffering, especially pain.

Pain is due to congestion and exudation as a result of dilatation of the peripheral vessels. The methods adopted, therefore, for the relief of pain should be in the direction of causing an absorption of the fluid which is already present and a prevention of a further exudation.

1. *Rest*, both physical and physiological, is essential and is often aided by the elevation of the part; this not only promotes the absorption of fluid, but also a reflex contraction of the arteries and thus a diminution in the exudation. The use of splints, slings, or even confinement to bed are strongly advocated. Beyond these, in a certain number of cases, no other form of treatment is necessary; if this is not sufficient, the following methods may be called for.

2. *The application of heat.*—This causes a general dilatation of the vessels, and thus a free flow of fluid to the parts, washing away the exudate. It may be applied in the form of hot water fomentations. A pad of wool is placed in a sterile towel in boiling water and allowed to remain there for a few minutes, then removed, the ends of the towel being twisted tightly so as to wring out the wool as dry as possible; then it is applied quickly to the part, covered with jaconet, and a pad of non-absorbent wool placed on the outside to keep the warmth in. It is not necessary to use any form of antiseptic in the fomentation; strong antiseptics, such as perchloride of mercury and carbolic acid, should be rigidly avoided. Treatment by fomentations is adopted invariably by many surgeons, and it is the most convenient method of applying moisture and heat.

A much better method, however, of dealing with inflammatory processes to which the application of heat is desirable is by the frequent use of hot baths at

a temperature bearable by the patient, in the intervening periods the affected parts being wrapped in large pads of dry sterile wool. This method is especially applicable in cases of microbic infection. Poultices should never be used in the treatment of surgical lesions.

3. *Cold.*—The action of cold is to diminish the exudation from the vessels by causing a contraction of the smaller arteries, thus diminishing the flow of blood; its use is indicated in the early stages only, as later on dilatation of the vessels is desirable in order to remove the products of degeneration. It is a soothing method of treatment, but is not so desirable as heat, except in cases of traumatic origin where it is necessary to limit extravasation of blood. It must be used cautiously, however, for it may so arrest the flow of fluid as to cause too great a diminution and subsequent gangrene of tissues. The method is carried out in various ways. Some prefer evaporating lotions, such as lead lotion, often with a little opium added; others the icebag, consisting of a piece of lint with lumps of ice wrapped in it; cold water kept continuously running through coils of lead (Leiter's tubes) has a similar effect, and is especially useful in certain regions of the body—for example, the head or the limbs.

4. *Aspiration.*—If exudation takes place into a cavity, such as a joint, tendon sheath or bursa, and by its tension causes pain, aspiration of the exudate by means of a hypodermic or aspirating syringe will always bring relief of pain; moreover, the method has the advantage in differentiating between serous and purulent effusions; it is superior to incision in that it does not leave an open wound.

5. *Incision.*—Incision acts in a similar manner to aspiration, namely, in relieving tension of the part, in allowing the blood to flow through the capillaries freely, and in the washing out of the exudate.

Similar results may be obtained by methods which fall little short of incision; namely, by the use of leeches, by the application of wet and dry cupping, by scarification of œdematous tissues, and the making of multiple punctures. Most of these, however, have gone out of fashion and been replaced by the methods above suggested. Their use is at times of considerable advantage in that they act as counter-irritants if applied to a part at some little distance from the initial focus of pain; they relieve congestion and diminish the circulation in the inflamed area. An excellent example is provided in certain forms of acute inflammation of the eye in which leeches are applied to the temporal region.

These methods of treatment can be equally well applied to inflammatory processes situated either on the surface of the body or in deeply-placed organs.

Other forms of treatment are adopted with the object, not of diminishing the inflammatory process, but of causing an increase so far as the local injuries are concerned—*e.g.*, it may be of advantage at times to bring about the formation of an abscess when such does not already exist. This is one of the objects of applying fomentations to acute inflammatory processes which have almost reached the stage of suppuration. A similar increase in the congestion of the part may be brought about by the application of elastic bandages on the proximal side of the lesion so adjusted as to cause a dilatation of the veins without compressing the arteries, and thus causing an excessive exudation of fluids containing antibodies into the tissues. The use of vacuum cups on the skin surface, as suggested by Bier, has a similar object and is often an advantage. This, however, should only be used when the inflammatory process has remained strictly localised to the

initial site of infection, and not when lymphatic and blood vascular dissemination has occurred.

*Constitutional treatment.*—There is no form of acute infection which does not call for certain internal remedies. In a case in which serious constitutional disturbances have arisen a lowering diet should be adopted. This, however, should not be carried too far; in weakly people, especially the aged, it may be necessary to institute a stimulating diet. In the former case milk, barley water, meat essence, custards and milk puddings are generally given. The use of drugs will depend very considerably on the site of the focus of inflammation. Purges are indicated in all cases, for they tend to lower the blood pressure and in this way to relieve the congestion of the inflamed area. Diuretics having as their object the elimination of toxins are always useful. The question of the use of local applications of antiseptics to the site of the original focus has already been mentioned, but should the process occur in the internal organs, *e.g.*, the alimentary or the urinary tract, antiseptic drugs applicable to those particular regions can be used with care. A few of the processes of inflammation require specific drugs, for instance colchicum in the treatment of gout, salicylate of soda in acute inflammatory arthritis, perchloride of iron in erysipelas, mercury in syphilis, and so on. Other drugs are used for the treatment of pain, such as aspirin, sodium salicylate, or even morphia. The loss of sleep demands bromide of potassium, sulphonal, chloral, paraldehyde, etc. Similar lines of treatment are called for in acute inflammatory conditions in which delirium is a marked symptom.

In those forms of inflammation necessitating the use of stimulants, essence of beef, eggs, oysters, "Plasmon," soup, white fish, and minced meat can be tried. Of the drugs quinine and iron, phosphorus, and strychnine are useful, whilst stimulants such as brandy, port wine, and champagne each has its advantage.

A stimulating form of treatment increases the action of the heart muscle and tends to drive the blood through the inflamed area. Its use is indicated when the pulse is feeble and frequent, the temperature high, and prostration is occurring. A dry, brown tongue is of itself a sign of considerable importance as an indication of what is required. In the young person with a good pulse and a moist tongue the lowering diet indicated is more applicable.

The desirability of using agents having the power to increase the production of antibodies may call for the institution of vaccine therapy; such has been proved to be of considerable service in certain forms of acute inflammation, *sensitised* vaccines prepared after the method of Besredka being advocated.

The use of antitoxins is not so valuable except in special isolated instances, *e.g.*, in the treatment of anthrax and diphtheria. Should the condition of the patient, however, suggest toxæmia, those micro-organisms for which known antitoxins exist should be antagonised by the action of such.

**Treatment of chronic inflammation.**—Whereas the treatment of acute inflammatory processes is mainly directed towards the alleviation of symptoms, the chronic lesions more often call for attention to the signs and local evidence of disease.

The methods of treatment mentioned in connexion with acute inflammation are all applicable to this group of cases. Removal of the primary cause, rest, elevation, and applications are all called for. In addition to these the following methods are in use:—

*Counter-irritation.*—This produces an active hyperæmia in the neighbourhood of the affected part; even the production of vesiculation is sometimes desirable. It is carried out by the local application of liquor epispasticus,

tincture of iodine, especially if mixed with the liniment, ung. hydrarg. co. (Scott's dressing) or burning with the actual cautery; fomentations with a few drops of turpentine added and mustard plasters have a similar effect. This method of treatment is sometimes beneficial.

*Pressure* by means of elastic bandages and strapping applied in overlapping strips (often combined with the use of Scott's dressing) prevents venous congestion and causes the absorption of fluid effusions. This is especially applicable in the chronic inflammation of joints.

*Massage*, combined with passive movements, is largely adopted for the treatment of chronic inflammation of joints, especially those cases in which there is a chronic effusion or fibrosis which resists other forms of treatment. The object in view is to induce a better return of the inflammatory products by the lymphatics and veins, to stimulate a better arterial supply, and to prevent the occurrence of fibrosis. It can be used in many other forms of chronic inflammation, but great care must be taken in selecting appropriate cases; suppurative conditions and those due to tubercle should be rigidly avoided.

*Passive congestion.*—The method suggested by Bier is especially useful in cases of chronic inflammation. It consists in the production of hyperæmia in the region of the affected area by preventing the return of blood and lymph. If the lesion is situated in a limb, an elastic band is placed around it on the proximal side, in such a manner as to obstruct the veins, but not the arteries; pain should not be produced. The limb becomes bluish-red in colour and slightly swollen. At first the patient can only bear this treatment for a short time, but later the periods of application can be increased even up to twenty-two out of the twenty-four hours. In those parts of the body to which bandages cannot be adjusted the same result can be obtained by the use of cups in which a vacuum can be produced. The same precautions must be observed.

*Active hyperæmia.*—This is best obtained by the use of hot dry air; the affected area is placed inside a suitable chamber filled with hot air produced by a variety of means dependent on the type of apparatus used.

*Radiotherapeutic methods.*—Electrolysis, ionisation, X-rays and radium have all been responsible for good effects.

*Balneotherapy* has many advocates, especially in the treatment of affections of the joints.

*General treatment.*—The methods already mentioned in dealing with acute inflammation are all used for the treatment of the more chronic types of disease. The diet in these cases, however, requires to be more stimulating and generous.

Certain drugs are specific for given conditions. Potassium iodide is regarded as being particularly useful in the treatment of any type of chronic inflammation in that it is said to have the power of producing the absorption of the products of the degenerative process. It is well known to have a beneficial effect in the treatment of syphilis and actinomycosis.

Serum and vaccine therapy are also more applicable in dealing with the chronic inflammations due to bacterial infection than those of acute origin.

**Vaccine therapy.**—A vaccine is a drug composed of an emulsion of dead micro-organisms in normal saline solution. The object of the preparation of such an agent is to liberate endotoxins from the interior of the micro-organism in such a manner as to free them from extraneous substances derived from the medium in which the micro-organism is growing; the latter substances are poisonous and harmful. It is not necessary to discuss here the various methods of preparation of vaccines.

At times it is desirable to use a vaccine which has been subjected to the action of the antitoxin of the micro-organism from which the vaccine has been prepared; such is called a *sensitised vaccine*.

An agent prepared from the micro-organism which is the cause of the infection in a particular case is known as an *autogenous vaccine*, as distinguished from a stock vaccine, which is one prepared from a micro-organism of the same type derived from another or several other cases.

The effect of introducing these agents into the body is to produce an active immunity—that is to say, to stimulate the formation of antibodies from the tissues of a patient so treated. It has been shown experimentally that the micro-organisms in a case of infection treated by vaccine therapy are rendered more liable to phagocytosis, presumably by the building up of antibodies.

Vaccines may be used as prophylactic agents in the prevention of infective lesions. It is well known that a typhoid vaccine is of some value in preventing typhoid fever. In conditions which are recurrent—*e.g.*, furunculosis, erysipelas, or gonorrhœal arthritis—the use of vaccine therapy between successive attacks often acts as a preventative. Some surgeons will go so far as to use vaccines before a severe operation in which it is known that infection is liable to supervene.

In the majority of cases, however, vaccines are used as agents in the treatment of bacterial infections. It is recognised that they are of greater service in some conditions than in others, but it may be broadly stated that they have not proved themselves to be such valuable therapeutic agents as was hoped.

First, it is essential that an accurate clinical and bacteriological examination of the case should be made before vaccine therapy is suggested. A careful estimate of the general condition of the patient and the exact nature of the lesion for which treatment is sought is necessary. The ordinary surgical methods of treatment in bacterial lesions must receive first attention, and *it must be understood that vaccines are only adjuvants to the ordinary lines of treatment*. As a general rule it is found that the chronic or subacute localised infections respond to treatment most readily, but at the same time under careful observation and judicious treatment vaccine therapy is of some service in certain acute generalised and localised infections.

The cases which respond best to vaccines and which give the most constant results are the chronic staphylococcal infections of the skin. Infections of the mucous membranes, especially the acute forms due to the staphylococcus, streptococcus, gonococcus, colon bacillus, or any other pyogenic micro-organism, do not respond so readily; symptoms are often alleviated, however, even when the condition cannot be cured. The beneficial effect on the constitutional condition of the patient is often very obvious, although no apparent change may be observed in the local lesion.

The dose of vaccine required is a variable quantity, but it may be taken as a general guide that the more acute the lesion and the more generalised the infection the smaller should be the dose of vaccine given. In the acute lesions larger doses can be given with sensitised vaccines than in the case of the unsensitised variety. A good general principle is to increase the dose with successive inoculations, but at the same time to await the result of each inoculation.

The advisability of using autogenous vaccines merits attention. It is undoubted that an autogenous agent is always better than one of the stock variety when it can be obtained, but the loss of time in preparing such may be an important factor in deciding as to its use. There are certain types of

infection in which it is known that a stock agent is almost as good as the autogenous variety—for instance, the staphylococcal lesions of the skin, erysipelas, which is constantly due to one form of streptococcus, or typhoid fever—but there are certain others in which the types of micro-organisms are so variable that no reliability can be placed on stock agents prepared from them To a certain extent polyvalent vaccines, that is, those prepared from a number of members of the same group, may be substituted. When an infection is due to more than one micro-organism a mixture of vaccines prepared from each should be utilised ; such a vaccine is said to be *mixed.*

*The results of inoculation.*—The hypothesis on which the value of vaccine-therapy is based has been mentioned above, namely, that a certain substance derived from the tissues of the body is produced in the blood serum which acts on the bacteria in such a way as to make them readily ingestible by the phagocytes. This antibody has been called by Wright the *opsonin.* A number of such substances are said to exist in the blood serum and to be specific for each micro-organism, and the object of the vaccine is to stimulate the formation of such a specific opsonin. It is probable that such a substance is not single but is a mixture of antibodies.

The immediate result of the injection of a vaccine into the tissues is to produce a fall in this antibody content which can be estimated by certain technical methods, and during this stage the patient is said to be in the *negative phase ;* this negative phase corresponds relatively to the amount of vaccine given, and during this period the patient is more susceptible to infection than before; it is immediately followed by a rise in the opsonin content, during which period the patient is said to be in the *positive phase.* The length of these periods is variable. Subsequently there is a period during which the opsonin content either remains at a certain level or gradually falls to normal. It is during this latter stage and before the return to normal that the second dose of vaccine should be given, when a similar reaction will occur, but as a result the negative phase will not be lowered to the same extent as on the previous occasion, and the positive phase will rise to a higher standard than in the first instance—in other words, the index will have been raised to a higher level and will tend to remain at such. The object of vaccine therapy is to arrange that the dose of vaccine injected shall give rise to the minimum of negative depression with a maximum of positive elevation, and eventually cause a permanent elevation of the index. In the more acute conditions no negative phase at all is desirable ; the summation of positive phases is the condition which should be aimed at. This theoretically is the process which results from the introduction of a vaccine, and the estimation of these phases was the means whereby we arrived at the practical administration of these agents.

In the early days of vaccine therapy the estimation of this opsonic content or opsonic index, as it was called, was carried out, but it is now recognised that it is not absolutely essential. Careful observations as to the clinical conditions present, both local and general, the chief signs being relief of pain and swelling, and the lowering of the temperature curve, are all that are necessary. Even the observation of this index as a guide to the size of the initial dose which should be given is no longer carried out. The knowledge that too large a dose has been given will be shown by unfavourable clinical signs, and it is in this way that the negative phase is recognised.

Vaccines are administered as a rule in doses of 1 c.c. containing a certain number of micro-organisms which have been carefully estimated numerically. They are given subcutaneously with due aseptic precautions, the

site usually chosen being the upper arm. The result as a rule is the production of a small patch of erythema around the site of inoculation which clears up within twenty-four hours. Occasionally a much more severe reaction is observed, but provided that the ordinary precautions have been taken, it is uncommon for anything in the nature of an abscess to be produced. With large doses of vaccine the patient may feel a little ill during the next twenty-four hours, but usually it is unnecessary for the patient to discontinue his ordinary course of life.

More will be said as regards the action of these agents under the various specific micro-organisms dealt with.

**Serum therapy.**—Serum therapy has the opposite effect to vaccine therapy, namely, it provides for the infected person antibodies already produced in the serum of a susceptible animal. The animal chosen for the preparation of a serum varies with each micro-organism. Sera are of two kinds—those which contain substances which are antitoxic and those which are antibacterial. Examples of the former are the sera of tetanus and diphtheria, and of the latter the sera of anthrax, dysentery, and plague. In the majority of the other micro-organisms the exact type of antibody which is produced is doubtful. Very few of these antisera are of much service. The value of diphtheria and anthrax antitoxins is well recognised; but, although the merits of others may not be obvious, at times most remarkable results follow their use.

Normal horse serum is often of considerable value as an agent in treatment.

*Methods of preparation.*—Sera are produced by the introduction of dead or living micro-organisms in increasing doses into the blood-stream of a susceptible animal. The process extends over a period of months or years until it is found that a certain standard of antitoxic or antibacterial power is arrived at. Unfortunately in a large number of cases of antisera no such standardisation is carried out. The serum of the animal is then withdrawn with due aseptic precautions, passed through a process of preparation, placed in ampoules and sold on the market. In these days it is possible to obtain sera which are antagonistic to most micro-organisms, and even the groups of such.

*Methods of introduction.*—There are many ways in which sera can be introduced into the body.

1. *Subcutaneously.*—The commonest method of introduction is into the subcutaneous tissues. By means of a large hypodermic syringe a puncture is made into the subcutaneous tissues of the anterior abdominal wall or loin and the serum thus supplied; if large doses are to be given several such punctures are made.

2. *Intravenously.*—It is advisable when the serum is given directly into the blood-stream that it should be introduced in combination with half a pint of freshly-prepared distilled water. If such a precaution is not taken certain inconvenient results, *e.g.*, rigors, may follow. The veins usually chosen for the introduction are the median basilic or median cephalic at the bend of the elbow. Before the introduction of the serum a little blood should be withdrawn in order to see that the needle is directly in the vein, otherwise leakage into the subcutaneous tissues will arise. It is unnecessary as a rule to dissect down on to the vein.

3. *Intramuscularly.*—Best given into the buttocks. Serum introduced by this method acts more rapidly than if given into subcutaneous tissues.

4. *Intradurally.*—In some diseases, *e.g.*, in tetanus and meningococcal infections, it is thought desirable to introduce the serum into the spinal

theca. A certain proportion of the cerebro-spinal fluid is removed by the ordinary process of lumbar puncture and replaced by a corresponding amount of antiserum. Occasionally it is introduced into the cerebral meninges after a trephining operation.

5. *Intracerebrally.*—Again, in the case of tetanus the serum has been introduced directly into the brain substance. A small hole is drilled in the skull bones, and the needle, by which the serum is to be introduced, is passed through; the fluid should only be allowed to flow very slowly.

6. *Per os or per rectum.*—Frequently serum is given by the rectum either alone or in combination with saline solution. Administration by the mouth has also been advised, but the value of this method is doubtful.

7. *As a local application.*—As a local application to infected wounds, a piece of gauze soaked in the serum has a remarkable effect. Normal horse serum seems to act equally as well as the specific sera for the various bacteria. In the case of carbuncles or cellulitis wounds the results are excellent. The disadvantage of this method is the expense which is incurred.

*Dosage.*—The dosage is a variable quantity. It is obvious that if sera are to be of any service at all they should be introduced at the very earliest stages of the infection, otherwise they will have no opportunity of neutralising the toxins produced in the blood-stream, or of slaying the bacteria which have invaded the tissues. Large doses should therefore be given at the earliest possible moment and repeated frequently. This will be dealt with in several sections later.

*Results of serum therapy.*—Occasionally harmful results are observed following the introduction of sera. That most commonly seen is known as *serum disease*, a condition which is demonstrated by the appearance of urticarial, erythematous, scarlatiniform or morbilliform rashes on the skin, pains in the joints, general malaise, and a certain amount of fever. These symptoms make their appearance from the fifth to the twelfth day after injection. Secondly, if too long an interval is allowed to exist between successive inoculations—for instance, three weeks—severe symptoms may arise after the introduction of the second dose; sudden severe collapse and occasionally death have been observed—this condition is known as *anaphylaxis*. This may follow even years after the introduction of the primary dose, so that it is important if one is desirous of introducing serum for some septic infection to inquire whether or not the patient has had previous inoculations.

## Suppuration.

Suppuration may occur either as a localised collection of purulent material, when the lesion produced is spoken of as an *abscess*, or it may spread amongst the connective tissue planes of the body, to become known as *cellulitis* or *diffuse suppuration*. Suppuration may also occur on the surface tissues of the body, namely, the skin, mucosa, or serous membranes: in the two latter situations, by virtue of their anatomical positions as lining membranes of serous or mucous cavities, localised suppurations are produced; these are frequently termed *empyemata*.

The modes of origin of a suppurative process are threefold—(1) the bacteria may be introduced directly into the tissues, as, for example, when a small subcutaneous abscess is formed after an infected wound; (2) it may arise by continuity, rupture, or lymphatic spread, from a suppurative process occurring in the neighbourhood—for example, a suppurative arthritis may follow the rupture of an abscess at the end of a long bone; or lymphatic

glands draining the primary focus may become involved; (3) an infected thrombus may be brought from some distant part of the body—such is spoken of as the *hæmic mode of infection*, and the lesion produced is termed a *metastatic deposit*.

It is important to remember these three modes of origin, for, although clinically the signs and symptoms observed are identical, the requisite line of treatment varies, and depends on the recognition of the origin of the suppuration.

Both the localised and diffuse forms of suppuration may occur in either an acute or chronic form.

It is sometimes difficult after recent contamination to differentiate between a suppurative and a non-suppurative inflammatory lesion, but as a general rule it may be stated that when an acute inflammatory process has persisted for three or more days without showing evidence of resolution, suppuration should be suspected; confirmatory clinical evidence should be carefully sought for.

**Acute localised suppuration or abscess.**—The signs and symptoms of acute inflammation, which have previously been somewhat diffuse in character, are noticed to become more localised to a particular area. The pain becomes intense and throbbing, although often subsiding when suppuration is well established; redness is marked; the swelling has a more or less definite outline; pitting on pressure will be observed owing to œdema of the tissues, a point of considerable significance in the case of a deeply-situated abscess cavity. As the suppuration approaches the surface of the body, in the centre of the swelling there appears one point more prominent than elsewhere, and often cone-shaped, softer and redder in colour, and, if tensely distended, more painful. An abscess exhibiting these features is said to be *pointing*.

Fluctuation, when exhibited in a condition having the characters of an inflammatory process, is a sign which is diagnostic of an abscess. The test should be carried out in the following manner. The fingers of one hand should be kept firmly pressed on a given part of the suspected area; a second point in the same area should be depressed by the fingers of the other hand, those first mentioned being kept motionless; an impulse will be felt against the fingers of the first hand. Great care is required not to mistake *false fluctuation* for the above; this can best be felt over well-developed muscles, if the manœuvre is made transversely to the muscle fibres.

In superficial situations transillumination by means of a light will help to differentiate purulent collections from those of a serous nature by the appearance of a dark shadow in the former.

To confirm the diagnosis, an aspirating syringe should be inserted with strict aseptic precautions into the softened area of the swelling, and in a case of suppuration pus will be withdrawn. This requires to be done with care so as not to injure important structures. This method of diagnosis should not be instituted when it is thought that the needle may have to cross a serous cavity in order to reach the abscess for fear of spreading infection. In all cases a careful examination should be made of the material obtained in order to identify the micro-organism which is the causative factor of the lesion.

Deeply-placed abscesses often give rise to considerable difficulty in diagnosis. Pain will usually be present both locally and referred along the course of nerves which may be in the neighbourhood of the abscess; it is increased if the muscles in the region of the suppurative process are put into action—*e.g.*, the psoas in the case of appendix abscess, the sterno-mastoid in the case of cervical abscess. Heat and redness, however, may be absent.

Swelling depends on the size of the abscess and the amount of displacement of tissues superficial to it. Pitting of the skin on pressure as evidence of superficial œdema is often the only distinctive feature observed; the value of this sign is well exemplified in the case of a perinephric abscess, which lies deep to those ribs over which pitting can frequently be demonstrated. Rigidity of the muscles over a suppurative process, although of little value in differentiating it from an acute inflammation, is frequently suggestive. In the case of intra-abdominal abscesses dulness on percussion in an area normally resonant is a valuable sign. An abscess cavity, especially if large, *e.g.*, in pleura, or intra-peritoneal, can sometimes be detected with the X-rays, but the interpretation of such pictures is often uncertain.

The involvement of the lymphatic glands and the appearance of metastatic abscesses elsewhere occur in the later stages of suppuration. An examination of the blood is sometimes useful in the diagnosis of obscure suppurative conditions. A considerable absolute increase in the number of leucocytes, especially those of the polymorpho-nuclear variety, is very suggestive; whereas normally the leucocytes circulating in the blood-stream number 5,000 to 10,000 per cubic millimetre, they may rise to 15,000 to 30,000 per cubic millimetre in suppurative conditions. In the more acute lesions, especially those associated with blood infection, a failure of leucocytic increase is regarded as an unfavourable sign.

The recognition of muco-purulent and sero-purulent inflammation depends upon similar methods of investigation applied to the special areas liable to infection.

*Clinical features of pus.*—The type most commonly seen in infective processes is thick and creamy. The older surgeons before the days of antiseptics and asepsis regarded its appearance in wounds as a favourable sign, and for that reason the term "*laudable pus*" arose. It may be thin and watery, being composed chiefly of serum with few cells; fibrin is prone to coagulate in such and form floating filaments in the fluid, hence the term "*fibrino-pus*"; if occurring in a glandular organ, mucus is a frequent content, hence the term "*muco-pus*"; *sanious pus* contains blood. Pus varies considerably in its colour: that most commonly seen is yellowish white, at other times it has a greenish tinge; golden-yellow pus suggests the presence of *staphylococcus pyogenes aureus*, thick green pus, the *bacillus pyocyaneus*. Granules appearing in pus suggest *actinomyces* as being the cause of the inflammatory condition. In the case of *tubercle* the pus is in the form of an emulsion containing flakes of cheesy material.

A fæcal odour suggests infection by intestinal micro-organisms, especially *bacillus coli communis* and *anaerobes;* probably the latter play the more important part in the production of this sign, as *bacillus coli* pus is frequently odourless. Gas may also be found in abscess cavities due to these bacteria.

The macroscopic appearances of pus should always be observed carefully, for they are useful in making a diagnosis of the nature of the infection.

*General signs.*—Suppuration is often preceded by a rigor. In all cases pyrexia and the associated symptoms of thirst, anorexia, constipation, and passage of scanty urine with diminished sweat secretion are observed. The pyrexia is of a remittent type, and continues so long as the pus remains confined within a cavity. It is dependent on the absorption of toxins from the lesion. Wasting, sweating, and anæmia subsequently develop. The pulse-rate is raised.

*Results.*—(1) An abscess may rupture spontaneously on to the surface, the pus be discharged, the walls of the cavity fall in, and the wound heal by

fibrosis of the granulation tissue, with the formation of a healthy scar. Healing may not occur, but a small track leading from the surface to the cavity and known as a *sinus* may persist. The suppurative process then takes on chronic characters lasting for a considerable period of time. (2) The abscess may rupture into an organ or tissue—*e.g.*, the peritoneum, a joint, a blood-vessel, or the bowel—and give rise to serious consequences. If it ruptures into cellular tissues diffuse cellulitis results. Should a track be formed between the skin and the bowel by rupture, as in the case of an ischio-rectal abscess, or between hollow viscera—*e.g.*, the bowel and the bladder—such is called a *fistula*. (3) A third mode of spread is by dissemination of toxins from the bacteria and the products of suppuration into the blood-stream, resulting in *toxæmia ;* or of the bacteria themselves, giving rise to *bacteriæmia ;* or of infected thrombi in surrounding vessels, producing *pyæmia*. (4) Very rarely the purulent material is absorbed.

**Chronic abscess.**—A term commonly applied to the condition is *cold abscess*. It may result from any of the causes which produce an acute abscess, but in which the virulence of the micro-organism of infection is much less, and the degree of resistance on the part of the connective tissues is increased. Most commonly, however, the tubercle bacillus is responsible for the condition ; the disease starts in a local focus, passing on to caseation, which is followed by a curious process of liquefaction. If this material is examined microscopically very few leucocytes are found, granular and fatty débris, together with some caseous material, forming the chief constituents. The pyogenic bacteria responsible for chronic abscess are *staphylococci*, *actinomyces*, *bacillus typhosus*, and certain of the *streptococci ;* these can only be recognised by systematic bacteriological investigation, both by film and cultural preparations ; the former is essential, because frequently the bacteria are dead and will be missed if cultivation only is carried out.

Tuberculous abscesses most commonly occur in young persons in connection with lymphatic glands, bones, and joints ; in adults the genito-urinary tract, pulmonary tract, &c., are also involved. Clinically they develop slowly around the primary focus of infection ; they may attain a very large size and gravitate to dependent parts of the body before giving evidence of their presence. Occasionally they disappear spontaneously, fibrosis and encapsulation occurring around the purulent material ; they may remain in this condition for many years, until some slight injury causes a lighting up of the inflammatory process, when what is termed a *residual abscess* is formed. On the other hand, the skin may become involved and eventually rupture, secondary infection supervene, and chronic suppuration persist. Such lesions are liable to cause amyloid disease.

The signs of inflammation beyond the production of a fluctuating swelling are frequently conspicuous by their absence ; the condition may not be recognised unless there is evidence of disease of the original focus, *e.g.*, caries of the spine, or unless the skin, nerves, or important viscera become involved.

Confirmation by aspiration is an exceedingly useful method of differentiation between a chronic abscess and other swellings which give rise to a sense of fluctuation, *e.g.*, lipomata, or true fluctuation, *e.g.*, cystic swellings.

The diagnosis from other forms of chronic suppuration due to pyogenic bacteria has been referred to. They may assume the characteristics of a tuberculous abscess, and can only be distinguished by bacteriological investigation. Constitutionally, chills, night sweats, wasting and anæmia are frequently observed.

The commoner sites for chronic abscesses are in the retropharyngeal region,

the psoas muscle, in bones, around or in joints, in cervical glands, in connexion with the ribs, in the lumbar region associated with spinal caries, in the kidney, ischio-rectal fossa, and subcutaneous tissues.

**Acute diffuse suppuration ; cellulitis.**—These terms are used to define those forms of suppuration in which the inflammatory processes diffuse rapidly through cellular tissues, particularly the subcutaneous and intermuscular planes. The infecting micro-organisms gain entrance to the body most commonly by direct inoculation through a wound. The wound may be quite trivial, or such a condition as a compound fracture may be the injury. Hæmic infection, direct extension from, or rupture of, an abscess, however, are also causes. The onset is as a rule sudden, being ushered in with a rigor or sequence of rigors, and all the symptoms of an acute infection make their appearance within a few hours to three days of the injury. The pulse is full and bounding, sweating is profuse, delirium often present, and the patient is extremely ill. Generalised infection by the blood-stream, either in the form of septicæmia or pyæmia, is extremely prone to occur in this condition, the patient dying within a week or ten days, with a feeble, rapid pulse, drowsiness and coma.

Starting from the site of injury the condition spreads rapidly, causing redness of the skin and marking out the lymphatic vessels as red lines (*lymphangitis*) running towards the lymphatic nodes. In places the skin becomes hard, brawny, intensely red, and later, as softening occurs, blue or even gangrenous ; pus forms in small collections which run together and travel in the subcutaneous and deeper cellular planes. When due to anaerobic bacteria, crepitus, known as *interstitial emphysema*, will be also observed. On the skin vesicles and pustules are often seen. The involvement of the intermuscular planes is recognised by the production of severe pain when an attempt is made to put the muscles into action. The lymphatic glands draining the area become enlarged, painful, matted together, and tend to suppurate. *Streptococci* are more often responsible for this condition than other bacteria. The prognosis is extremely grave.

**Treatment of acute abscesses.**—Before treating suppurative conditions an accurate and exact diagnosis must be made. The site of origin of the inflammatory process, the extent to which neighbouring structures have become involved, and the possible infection of the blood-stream and distant tissues of the body all require to be known. It is not always possible to define these points with exactitude, but an attempt should be made to do so.

*Prophylaxis.*—The prevention of suppuration is of great importance. It is most likely to occur when an open wound is contaminated with bacteria, especially those of the pyogenic variety. Every open wound passes through an aseptic inflammatory reaction in the process of healing, and therefore the greatest efforts should be exerted to avoid possible infection with micro-organisms. Every wound which has been accidentally produced should be regarded as being possibly contaminated with bacteria; it requires to be cleansed together with a wide area of skin around it, and dressed with aseptic dressings. Excision of damaged tissues may be called for in cases of severe injury. Precautions of this type, when efficiently carried out, usually prevent the onset of suppuration.

The use of vaccines and sera introduced into the tissues is indicated in conditions when the infection or possible infection is known, *e.g.*, in the case of streptococcal infections, anthrax, and tetanus ; some surgeons even go so far as to deal with all wounds liable to contamination with bacteria on these lines, but there is little evidence as to the beneficial value of the treatment.

*Stimulation of suppuration.*—Sometimes it is considered desirable to bring about suppuration in acute inflammatory lesions, especially in those cases in which infection is prone to spread rapidly in the local tissues or in the blood-stream.

The application of heat in the form of hot fomentations or hot baths tends to cause a suppurative process to point at the site of weakest resistance. Bier's passive congestion treatment, the application of elastic bandages, Bier's cups, or "antiphlogistin" have the effect of promoting suppuration. In cases of recurrent metastatic suppurations the production of an aseptic abscess by the injection of some irritant fluid, *e.g.*, turpentine, into some unaffected part of the subcutaneous tissues, is said to be beneficial in stopping the process.

*As soon as the presence of suppuration is recognised the purulent material should be evacuated from the cavity containing it. It is inadvisable to wait until it points or even gives evidence of fluctuation.* An abscess should never be allowed to rupture, as a disfiguring scar will result and a sinus may persist. In the majority of cases gas and ether anæsthesia is requisite in order to deal efficiently with the condition, no matter how trivial it may appear to be. Local anæsthetics are seldom advisable, as their use is liable to lead to inefficient treatment. Strict aseptic precautions must be observed, as in dealing with a non-infected tissue. An incision is made of sufficient length in the most dependent part of the cavity in order to obtain efficient drainage, and should be preferably in the lines of the natural folds so as to avoid the production of a visible scar. If possible the whole of the interior of the abscess cavity should be seen through the initial incision. Pockets of pus leading from the main cavity should be sought for and opened up. If there is an obvious cause for the condition—*e.g.*, a bullet, a sequestrum, or the appendix vermiformis—this should also be removed. Allow the pus to run out of the cavity; do not squeeze it, or scrape the granulations from the wall, as they act as a barrier to the spread of infection. Some surgeons swab over the wall of granulations with pure carbolic acid and subsequently irrigate with normal saline solution; the former is unnecessary, but the latter, if carefully done, is often useful in removing pus from the corners.

In the case of deep-seated abscesses it may be difficult to make large incisions owing to the proximity of important structures; under these circumstances a small incision is made through the skin and deep fascia over the suspected area; a director is then inserted through the soft tissues until pus is seen to pass along the track; a pair of pressure forceps is passed along the director until it reaches the cavity; the forceps is then opened so as to dilate the orifice of the abscess and release the purulent material (*Hilton's method*). Deep-seated abscesses in the peritoneal cavity require to be approached with caution owing to the possibility of setting up general peritonitis or causing injury to the intestines. The general cavity is either packed off from the region of the abscess, or the wall of the latter is stitched to the parietes before the pus is evacuated; the operation may be carried out in two stages. In the treatment of large abscesses it is advisable to make incisions (counter-incisions) in more than one situation so as to obtain free drainage. Drainage should be carried out by means of rubber tubing. Gauze should never be used except as packing when excessive bleeding follows the incision. Careful provision should be made not to allow the tube to fall into the abscess cavity, either by stitching to the skin or by passing a safety pin through it.

*After-treatment.*—If the abscess is situated in a limb, the part should be placed absolutely at rest by splinting if possible. Within six hours the dressings

should be removed and the limb placed in a bath of hot water at a temperature as hot as the patient can comfortably bear it for half to one hour. If impossible to do this on account of the site of the lesion, hot fomentations, hot water bottles, or radiant heat can be substituted. Dry dressings of plain sterilised gauze should then be applied. This process should be repeated every three hours. Within twenty-four to seventy-two hours the tubes should be removed, the time depending upon the size of the cavity and the collapsibility of its walls, thus allowing the granulations to fall together. In bone abscesses drainage requires to be carried on for a longer period, owing to the rigidity of the abscess wall. In very small abscesses drainage may not be necessary at all. Under no circumstances should gauze be used as a wick, for it only gets clogged with purulent material and acts as a " plug " rather than a means of drainage.

Bier's treatment, either by bandage or by cup, often serves to hasten the healing of the wound after the acute stages have passed off.

Irrigations are seldom necessary, except in the case of large abscess cavities from which it is desirable to remove débris ; saline solution following a preliminary wash-out with hydrogen peroxide is all that is necessary. Continuous irrigations are sometimes indicated. The use of strong antiseptics is to be avoided.

**Treatment of chronic abscesses.**—The commonest form of chronic abscess met with is that due to the tubercle bacillus. The general rule in the case of acute infections that an abscess should be opened as soon as it is diagnosed does not hold good here. There are various methods of dealing with such, but the selection in an individual case depends largely on the possibility or otherwise of carrying out adequate general treatment.

1. The most efficient method is complete *excision* of the abscess and its cause. An example of this is tuberculous adenitis cervicis, when the glands affected and the abscess cavity can be removed completely. Again, suppuration occurring in connexion with tuberculous joints in persons between fifteen and thirty years of age is sometimes well dealt with by excision of the joint.

2. *Aspiration* is an excellent method of treatment under suitable conditions. It should be carried out, if possible before involvement of the skin has occurred, as follows : A considerable area of skin around the point selected for puncture is prepared by washing with acetone and iodine ; a trocar and cannula to which a syringe can be attached are then inserted into the cavity, passing first through healthy tissue and avoiding the place at which the abscess is attempting to point. The trocar is then withdrawn and the purulent material allowed to flow out ; if it does not run freely, the syringe is affixed and gentle suction applied. The appearance of blood is an indication that the needle should be withdrawn, otherwise the cavity will fill with blood, a condition to be avoided. It is not necessary as a rule to wash out the cavity or introduce any antiseptics. If the material cannot be withdrawn owing to its thickness, an attempt can be made to liquefy it by the introduction of a mixture of thymol (one part), camphor (two parts), and sulphuric ether (three parts), which is left in the cavity for twenty-four hours to a week. The process is then repeated. Aspiration may require to be carried out from six to twenty times.

3. The abscess may be opened freely so as to expose the whole of its interior. The tuberculous material should then be removed together with sequestra, or breaking down glands, by means of a gouge or scoop. Bleeding points should be dealt with, the whole swabbed out with iodoform emulsion and the wound completely sewn up ; drainage should never be used unless

secondary infection has already taken place or the skin has become involved. Even in the latter condition the affected skin can be excised so as to permit of complete suture.

4. If small, the abscess may be left alone in the hope that it will disappear; this does happen frequently. Such conservative treatment is highly desirable in tuberculous infections, but considerable judgment is required in the selection of the proper cases.

5. Bier's treatment, either by bandage or suction, is also applicable to these conditions.

6. Similar lines of treatment can be adopted in cases of chronic localised suppuration due to pyogenic bacteria, if they are under observation, often with unexpectedly good results.

**Treatment of diffuse cellulitis.**—Prophylaxis plays an exceedingly important part in the treatment. All wounds which have been subject to contamination with bacteria should be opened up freely or completely excised, washed with mild antiseptic lotions, and drained; if the wound has been satisfactorily excised, it may be sutured; if there is any doubt, it may be packed with gauze soaked in an antiseptic such as flavine, or treated by the Carrel-Dakin method, and delayed primary suture adopted within twenty-four hours. If cellulitis appears, the ordinary methods of dealing with inflammatory processes should be adopted with the object of aborting a spread of the infection. If this fails, free incisions several inches in length should be made in the direction of the vessels and nerves over the whole area of the lesion, in order to give free exit to the exudation; all localised or diffuse collections of pus should be evacuated. Free drainage with tubing, and not gauze, should be aimed at. A limb should be placed in a bath of hot water and kept there for a considerable period of time, varying with individual cases, and in the intervals dressings of sterile gauze and a splint applied, the latter to prevent contractures. Frequent hot baths or continuous irrigation are very desirable. In desperate cases amputation above the lesion may be necessary, especially if septicæmia or pyæmia is suspected, but the condition of the patient must be bad indeed if this method of procedure is called for. Careful observation for the appearance of metastatic abscesses either in lymphatic nodes or elsewhere should be made and these dealt with as soon as they are recognised. The after-treatment is similar to that used in localised suppurative conditions. Massage and early passive movements should be commenced as soon as possible to prevent adhesions occurring, and to limit the contraction of scar tissue of the skin or deeper tissues.

*General treatment.*—The constitutional treatment of suppurative processes is on the same lines as that adopted in all cases of acute inflammation. After the acute symptoms have passed off stimulants, tonics, nutritive diet and plenty of fresh air are indicated. Vaccine therapy and serum therapy are sometimes useful.

**Constitutional effects of inflammation and suppuration.**—These may be classified conveniently under the heading of *Traumatic Fevers*. Of these there are two main varieties—the aseptic and the septic. The former includes the fevers associated with contusions, wounds, burns, sprains, fractures, and operations, the latter toxæmia, septicæmia, and pyæmia.

*Aseptic traumatic fever.*—This depends on the absorption of certain substances from the tissues injured under such circumstances as those above mentioned. The symptoms come on within twenty-four hours of the injury and as a rule are quite trivial; there is a feeling of chilliness, rise of temperature of a degree, very occasionally a rigor, together with general malaise,

anorexia, and sleeplessness. The condition usually subsides within a few hours, but may last for two days; should it continue or recur, the presence of some other source of fever, *e.g.*, infection with bacteria, should be suspected If the condition is severe, the wound should be examined in order to exclude the possibility of infection having occurred.

Treatment is on the lines of conservatism; the bowels should be opened with calomel or castor oil on the second day. Pain should be relieved by the use of sedatives, sleep induced by hypnotics, and a light diet should be instituted during this period. The wound should be treated on the lines indicated elsewhere.

*Septic traumatic fevers.—Toxæmia.*—A *toxin* is an excretion of living bacteria or a product of degeneration of killed bacteria and cells taking part in the inflammatory process. These substances are absorbed by the blood and bring about certain changes which are classed under the heading of *Toxæmia.* It is very difficult to be certain that the condition is so simple as this, for it is obvious that when bacteria are bringing about inflammation, especially suppuration, their relation to the blood vascular system is very intimate; it is probable, therefore, that a certain number of them are absorbed in the living state into the blood, there to be slain by antagonistic substances. Clinically, however, the condition can be regarded as one in which the majority of bacteria remain at the site of the original focus of infection, the toxins only being absorbed by the blood. The resultant effect of the absorption depends on the virulence of the infecting micro-organism and the power of neutralisation possessed by the patient's serum. The clinical condition is the same as that occurring in aseptic traumatic fever, except that it persists, causes anæmia by destroying the red blood cells, and if allowed to continue may pass on to septicæmia. The condition will subside if the primary focus is adequately dealt with. In certain well-known infections—*e.g.*, anthrax, tetanus, diphtheria—it is known that the constitutional effects are due to the toxins of these bacteria; the use of corresponding antitoxins is strongly indicated; in the majority of cases a successful result ensues.

*Bacteriæmia.*—This term is used to indicate that the micro-organisms are known to be present *and multiplying* in the blood-stream, and in the tissues apart from the primary focus of infection. It is usually termed *septicæmia*, but this term is misleading. It is in reality a further stage of the above-mentioned condition, namely, that large numbers of micro-organisms obtain access to the blood and lymphatic channels, where they meet an insufficient quantity of antibodies or phagocytes to resist their invasion. The toxins, therefore, are able to exert a much stronger effect on the tissues. The condition is due most commonly to infection by the *streptococcus pyogenes*, sometimes a staphylococcus, and occasionally other bacteria. Chronic forms of the condition are recognised.

Puerperal uterine infections, lateral sinus thrombosis, acute osteomyelitis, subcutaneous cellulitis, septic forms of scarlatina, acute miliary tuberculosis, and post-mortem room wounds are most commonly associated with the acute form of bacteriæmia. Occasionally it supervenes in clean surgical operations without obvious reason.

Chronic bacteriæmia may be associated with such conditions as chronic osteomyelitis, typhoid cholecystitis, pyorrhœa alveolaris, chronic cellulitis, and chronic endocarditis.

In acute forms of bacteriæmia the micro-organism is admitted through an original focus, which may be quite trivial. Within a few hours there is a sudden onset of fever, usually with an initial rigor. The temperature is of the

remittent type and remains as a rule from 103° to 104° F., rising to its highest point just before death. The rigors are not repeated unless pyæmia is also present.

Owing to the effect on the heart muscle, the pulse, which is full and bounding in the early stages, rapidly becomes small and feeble at a rate of 130 to 150 per minute.

Headache, malaise, dry tongue, sordes on lips, anorexia, thirst, constipation, sometimes diarrhœa, and albuminuria are accompanying symptoms; delirium and mutterings are frequently present. The patients commonly die in a comatose condition.

On examination in the early stages the patient's face will be flushed, the skin being dry and hot; later it becomes pale, clammy, the eyes sunken and lustreless; profound anæmia rapidly ensues; a jaundiced colour of the skin is noticed owing to destruction of the red blood cells; a scarlatiniform or petechial cutaneous rash will be observed, especially on the trunk. Hæmorrhages from mucous membranes and kidneys also occur. The spleen will be enlarged.

A blood cultivation should be made, at least 5—10 c.c. of blood being withdrawn from a vein and cultivated in graduated amounts; the presence of micro-organisms confirms the diagnosis, but frequently, even in the advanced stages, the result is negative. Sometimes the micro-organism of infection can be isolated from the urine. An attempt should always be made to obtain it in pure culture from the original focus.

The prognosis of the condition is always extremely grave.

In the post-mortem room, besides the conditions mentioned above, the cells of solid viscera are found to be in a condition of fatty degeneration; minute subserous hæmorrhages and recent vegetations on the heart valves can be frequently demonstrated; micro-organisms can be isolated from the heart's blood, spleen, which is soft and diffluent, and other viscera. All the organs are congested, but no other macroscopic lesions as a rule are present.

*Chronic bacteriæmia* is closely allied to toxæmia, but it differs from it in that it persists for a considerable period of time, bacteria being frequently found in other parts of the body producing secondary lesions.

The condition was formerly regarded as being of the nature of a toxæmia, but probably the presence of bacteria in small numbers in the blood-stream is responsible for the conditions found.

It depends on the fact that there is an improper drainage of an abscess cavity or a difficulty in dealing with the initial lesion owing to its position, *e.g.*, the prostate in gonorrhœal septicæmia. The fever may be quite insignificant; as a rule it is of the type spoken of as hectic fever, in which there is an evening rise to 101° to 102° F., associated with sweating, with a fall in the morning. As the condition progresses wasting, anæmia, and even amyloid disease are prone to occur. Chronic endocarditis is frequently met with.

*Treatment.*—Prophylaxis plays a very important part in the treatment of bacteriæmia. Rigid attention should be paid to the carrying out of strict aseptic precautions in all surgical operations; avoidance of clean surgical operations on persons who have infective lesions, however trivial; local cleanliness, asepsis and antisepsis, in the treatment of all wounds must be observed.

Local treatment should be directed towards obtaining free drainage or removal of the damaged tissues at the site of the primary focus, and efficient after-treatment, as indicated under the headings of *Acute Inflammation* and *Suppuration.*

As regards general treatment, the diet should be nourishing and stimulating. Considerable quantities of fluid should be given either by mouth, rectum, or subcutaneously, and in more serious cases intravenous infusions of normal saline solution. To this latter may be added normal horse serum in large doses (50 c.c.) or a serum corresponding to the infecting micro-organism: unfortunately most sera on the market are of little service; anti-anthrax and antistreptococcal sera are perhaps the most encouraging. Brandy and champagne are the best forms of stimulant to use and may be given with advantage in large quantities. Vaccines have been employed with considerable success in large numbers of cases, but in an equally large series no benefit has been derived; their position in the treatment of these conditions is not fully defined. Strychnine and phosphorus are the best drugs. Antipyretics are seldom desirable, as they have a depressant effect; spongings and icepacks are infinitely preferable for the reduction of fever. Hypnotics are indicated for sleeplessness and delirium.

The same lines of treatment should be used in cases of chronic bacteriæmia, but these are more liable to respond to the effect of local surgery at the site of the primary lesion. Vaccine therapy is of much greater service. Fresh air and tonics are of primary importance.

*Pyæmia.*—Around the site of an acute inflammatory or suppurative lesion the blood-vessels become inflamed (*phlebitis*) and subsequently thrombosed. The thrombus lying inside the vessels is liable to be invaded by micro-organisms responsible for the primary lesion; this causes softening, suppuration, and loosening of the clot, which is carried off in the blood-stream, together with bacteria, to some other part of the body. When the clot, known as an *embolus*, reaches a vessel through which it cannot pass, usually a small artery in the lungs, a blockage takes place and consequently a cutting off of the blood supply of the area it supplies, forming an *infarct*. The micro-organisms here set up a suppurative process in the clot; inflammation of the blood-vessel wall follows, with liberation of bacteria into the surrounding tissues and subsequent abscess formation. Abscesses formed in this way are called *pyæmic* or *metastatic abscesses*, and the condition in which one or a number of such make their appearance in various parts of the body is called *pyæmia*. The presence of an embolus is not essential, as the micro-organisms themselves may be held up and originate foci of suppuration.

Though essentially the same process is occurring, two types of pyæmia can be recognised; when the affection starts in regions drained by the portal vein, *e.g.*, suppuration or ulceration connected with the intestinal tract, the metastases are most frequently found in the liver; hence the term *portal pyæmia*, in contradistinction to *systemic pyæmia*, originating from foci in other parts of the body.

Among the causes of portal pyæmia, appendix abscess, suppurating or gangrenous hæmorrhoids, may be mentioned; of systemic pyæmia, otitis media with lateral sinus thrombosis, uterine infections following childbirth, and bone suppurations are common examples. Acute malignant endocarditis is a special cause.

The *staphylococcus pyogenes aureus* is more commonly responsible for this condition than other bacteria so far as systemic pyæmia is concerned, the *bacillus coli communis* and *fæcal streptococci* for portal pyæmia. *Streptococcus pyogenes* is frequently found in cases of pyæmia secondary to otitis media and post-mortem room cellulitis. *Typhoid bacilli* are found in joint, bone, and blood vascular lesions following enteric fever. The *pneumococcus* is often

responsible for pyæmic joint conditions. Mixed infections are of frequent occurrence. Acute miliary tuberculosis is a similar condition.

In systemic pyæmia the commonest metastases are to be found on the surface of the lungs, frequently associated with localised pleurisy or empyemata. Abscesses are also found in the joints, subcutaneous tissues, heart muscle with accompanying pericarditis, kidneys, lymph nodes, spleen and brain. Any organ may be affected. Ulcerative endocarditis is a common complication. In portal pyæmia the liver and spleen most commonly become riddled with abscesses which are found around the vessels of the portal tract. From these further spread may take place to other tissues of the body. In association with abscess formation the lesions found in a case of bacteriæmia are also seen.

*Clinical signs and symptoms.*—The onset usually occurs about a week to ten days from the date of infection. It is ushered in with a severe rigor lasting from five minutes up to an hour; the temperature rises to 103° to 105° F., and the rigors recur frequently, often many times a day. Following each rigor there is a period of profuse sweating with accompanying exhaustion. The temperature chart consequently shows very marked intermittent irregularities. The pulse-rate is rapid and feeble. The facial expression of the patient is anxious and earthy; the eyes are lustreless and sunken. The tongue is red, glazed and dry; the breath has a sweet odour. The other signs of bacteriæmia are present—petechial rashes, delirium, diarrhœa, and coma just before death. A local suppurative focus or one of the conditions above mentioned will usually be found. Careful observation must be made for the formation of metastatic deposits, which will be obvious only if they are of considerable size; a cough, with sputum containing blood and pus, with clinical evidence of broncho-pneumonia, and later, empyema; a pericardial effusion; heart murmurs as evidence of ulcerative endocarditis; subcutaneous and joint abscesses; enlarged spleen; hæmaturia and pyuria due to renal infarct, must be sought for. In cases of portal pyæmia a painful enlargement of the liver with symptoms of toxæmic jaundice is noted. Systematic examinations must be regularly carried out, otherwise these conditions may be missed, as the patient is often not conscious of any symptoms which will suggest the presence of a lesion, the abscesses being characteristically painless in their formation. Blood cultivations demonstrate the presence of bacteria; the same micro-organism as is responsible for the primary lesion will also be found in the metastatic deposits.

A chronic form of pyæmia is recognised in which it is often difficult to find a primary focus. It has similar characters to the acute form; it may be due to staphylococci, typhoid bacilli, or actinomyces, and is characterised by the appearance of multiple recurrent abscesses in subcutaneous tissues and joints or bones. Fever is hectic in type and devoid of rigors. Death from lardaceous disease, or involvement of an important organ, frequently occurs.

*Prognosis.*—The prognosis is as a rule extremely bad in most of the acute types of infection; typhoid and pneumococcal pyæmias sometimes resolve. In the majority of cases the patient dies from exhaustion, even though the local condition is dealt with vigorously, and metastatic abscesses are freely and efficiently drained. Sometimes, however, even after a prolonged period of infection, most remarkable recoveries take place. The prognosis of the chronic form is less serious. It is only by the early recognition of pyæmic symptoms in connexion with conditions known to be responsible for their origin that it can be hoped to save the life of the patient.

*Treatment.*—The treatment is threefold:—(1) The primary focus of infec-

tion must be dealt with at the earliest possible moment. A wound or localised suppurative lesion must be freely incised and drained; a thrombosed vein should be ligatured on the proximal side of the thrombus, and where possible, as in the case of a localised clot, this should be removed; if the end of a long bone is the source of infection, the desirability of local incision and drainage as compared with amputation must be discussed. (2) Careful investigation for and recognition of metastatic deposits must be carried out; if such are found, they must be dealt with as soon as possible; pleural, pericardial, arthritic, or subcutaneous effusions must be treated on the lines indicated elsewhere. (3) Stimulation of the forces of resistance of the body tissues must be attempted by methods similar to those used in cases of bacteriæmia, especially with the object of preventing the formation of multiple and recurrent lesions. Vaccine therapy and serum therapy frequently bring about surprising results.

**Amyloid or lardaceous disease.**—This is a degenerative process occurring in various organs of the body, complicating long-standing suppurative conditions, especially those in connexion with pyogenic, tuberculous and syphilitic affections of bones and joints.

The disease is manifested by the deposition of a nitrogenous substance known as *lardacein*, having the chemical composition of *chondroitin-sulphuric acid*, in the middle coats of the smaller arteries. It is a colourless, waxy material. The organs most frequently affected are the liver, spleen, kidneys and intestine; in the later stages any of the body tissues may become involved. The organs become enlarged, so that they retain their natural contour, but are firmer, heavier, and have rounded margins. The cells of the organ are not subject to the lardaceous deposition, but undergo a process of fatty degeneration due to pressure, and diminution in blood supply. If seen in the post-mortem room the condition can be recognised by the waxy appearance of the organs; when stained with iodine they take on a mahogany-brown coloration. Sections of the tissues stained with methyl violet show a pink coloration of the lardaceous material.

*Clinical condition.*—All patients suffering from long-continued suppurative processes should be examined from time to time for evidence of this condition.

1. The patient assumes a curious waxy appearance of the skin of the face.
2. Anæmia is considerable, and is of the secondary type.
3. The liver is felt to be enlarged, frequently down to the level of, or below, the umbilicus. The organ feels firm and smooth, with rounded margins. In the later stages ascites, and distension of the blood-vessels of the abdominal wall to produce a compensatory circulation, are present, but jaundice is an infrequent sign.
4. The spleen is enlarged, smooth, and has rounded edges; the notch is usually retained.
5. The kidneys are enlarged, but usually cannot be felt. Their involvement is recognised by the appearance of albumen in the urine, the presence of waxy casts, polyuria, lowering of the specific gravity, and occasionally hæmaturia.
6. Watery diarrhœa is evidence of affection of the alimentary tract.

*Prognosis.*—If the source of suppuration is removed and the condition is not too far advanced, recovery will take place. If, however, the cells of the organs involved have become completely destroyed, recovery is not possible.

*Treatment* consists in the removal of the local focus of suppuration. This can be done by removing sequestra or other primary causes, or even amputation.

## Ulceration and Ulcers.

An ulcer is an infected sore of a surface tissue, in which the processes of destruction and repair are going on coincidently, so that there is little or no tendency for healing to take place. Any superficial loss of tissue, invaded by bacteria, would come under this heading. The process of formation of an ulcer, spoken of as *ulceration*, is similar in character to that which occurs in the formation of an abscess cavity, except that there is no external wall to the lesion, the granulation tissue lying exposed on the surface; it is also similar to that occurring in gangrene, except that it is a molecular death of tissue rather than massive necrosis. Ulcers may form either on the skin or on mucous surfaces.

The presence of a micro-organism in the lesion is essential for the formation of an ulcer; but in the majority of cases some predisposing factor exists.

*Causation of ulcers.*—The causes of ulceration must primarily be classified under two headings—1. Predisposing causes, which include any condition placing the tissues of the body in a lowered state of resistance to infection or injury—for example, persistent fevers, general wasting diseases, diabetes, or chronic Bright's disease.

2. Exciting or local causes; these may be grouped as follows:—

(*A*) *Any condition which prevents a proper circulation of the blood-stream through the tissues.*

(1) A diminution in blood supply or in blood return, *e.g.*, the presence of varicose veins.

(2) Lesions of either central or peripheral nervous system, acting by their loss of control on the circulatory system; such are called trophic ulcerations.

(3) Pressure on certain parts of the body, especially bony prominences, as by plasters, growths, gouty tophi, or decubitus. The presence of stagnant substances, *e.g.*, fæces and urine, which cause soddening of epithelium behind obstructions, may be placed in this class.

(*B*) *Ulcerations which have some specific micro-organism responsible for their formation.*—These include (1) those due to pyogenic bacteria, (2) tubercle bacillus, (3) spirochæta pallida, (4) actinomyces, (5) glanders bacillus, (6) diphtheria bacillus, (7) typhoid bacillus, and some others. In most of these instances, although a specific microbe is responsible for the production of the lesion, secondary infection with other pyogenic bacteria almost invariably occurs, and maintains the inflammatory process.

(*C*) *Ulcerations due to growths.*—Carcinomatous ulcerations starting in the superficial tissues or by infiltration from deeper structures are most commonly met with. Sarcomata and rodent ulcers are also examples. When innocent tumours produce ulceration it is usually by pressure and thus by deprivation of the superficial tissues of their blood supply.

(*D*) *Ulcerations due to trauma*, including injury by instruments, bites, teeth, foreign bodies, burns, those due to X-rays, radium and acids; cold or heat is responsible for a large number of lesions.

Ulcers have certain points in common; they have a base, with surrounding margins varying in character; around the ulcer there is usually an inflammatory zone and often secondary changes in the tissues; from the surface of the ulcer exudation occurs.

Careful observation of each of these points often leads to the differential diagnosis between the types above mentioned.

The *base of the ulcer* may be slightly depressed or raised above the surface: it may be soft, firm, hard, or warty; it may bleed readily or not at all; it may

be covered with flat or exuberant granulation tissue, dark red or pale in colour, or with fibrous tissue or a slough.

The *edges* exhibit definite characters, often suggesting the cause of the ulceration. They may be smooth, shelving, clean cut, irregular, ragged, hard, soft, raised, undermined, or everted.

The *exudation* or discharge may be serous, sero-purulent, purulent, sanguineous, foul in odour, odourless, pigmented, or contain granules.

The *surrounding tissues* may or may not be affected. Œdema, eczema, induration, acute inflammation, bogginess, or infiltration may give useful information. Some important structure, such as a blood-vessel or a nerve, may become involved; periosteum and bone may show secondary changes, and so forth.

The number of ulcers present is of some importance; as also is the position of the lesion, for certain types of ulceration are known to occur in particular situations.

The results of an ulcerative process are variable. Firstly, the ulcer may heal; the granulations show a healthy character, and the epithelial cells from the margins creep over its surface until a thin film-like structure is produced forming a complete covering for it. The fibroblasts in the granulation tissue convert it into fibrous tissue coincident with this process, so that a "*scar*" is formed: this may be white or pigmented; it may remain flush with the surface or be depressed and drawn in, according to the depth and type of the original process.

Under other circumstances the ulcer refuses to heal and runs a chronic course. Such a one is liable to involve deeper structures, to produce secondary effects on underlying tissues, and even to develop malignant changes in its structure.

Certain terms which require explanation are used clinically in connexion with ulcers:—

A *healthy* or *healing ulcer* is one having red, firm granulations covering a slightly depressed base, with a smooth, shelving, regular white or bluish margin. The discharge from its surface is odourless, serous, or slightly blood-stained if it has recently been touched. The surrounding tissues are natural, and the underlying tissues are not involved.

An *unhealthy* or *indolent ulcer* has pale, flabby, gelatinous, semi-translucent granulations with thin, undermined, irregular edges, over the surface of which scabs of dried secretion are found. The surrounding tissues are often soft, boggy and inflamed. The discharge is thin, watery and purulent.

A *painful ulcer* is one exhibiting the symptom of pain due to the exposure of a nerve on its base.

A *fissured ulcer* is so called on account of its elongated slit-like appearance, and is most commonly met with along the anal margin or on the tongue.

A *perforating ulcer* has a base which extends deeply into the tissues towards the neighbourhood of the bone and joints, and is usually associated with some form of nervous disease.

A *phagedenic ulcer* is one in which the destructive process extends extremely rapidly, often involving a considerable area, causing sloughing and destruction of the tissues.

A *fistulous ulcer* is one occurring at the mouth of a fistula.

A *serpiginous ulcer* is produced by the fusion of a number of small ulcers to form a crescentic ulceration which spreads by a convex margin.

Other terms are applied to ulcers according to their situation, *e.g.*, dental, peptic, duodenal, gastric, intestinal, crural, and so forth.

Two main types of ulcer are recognised, namely, (1) acute ; (2) chronic.

(1) *Acute ulceration.*—Most forms of ulceration go through an acute stage, but under this heading should be classified those which progress rapidly and show a tendency to heal unless they involve some important structure during the course of their formation. A multiplicity of ulcers is often a feature. They are more often seen in connexion with mucous membranes than skin structures. Simple examples are the peptic ulcers in the mouth and those following trauma. Of the more severe types, acute gastric and intestinal ulcerations may be mentioned.

Phagedenic ulcers are classified under this heading. In this condition the ulceration spreads extremely rapidly, often involving a considerable area, and leading to marked sloughing and destruction of the tissues. In former days it was commonly seen in connexion with wounds obtained in battle, the infection, which is due probably to an anaerobe associated with other pyogenic bacteria, spreading in epidemics. Nowadays it is usually associated with neglected venereal sores. The base of the ulcer is devoid of granulations and is covered with a foul, green slough, from which exudes dark blood-stained, ichorous fluid ; the edges are irregular, undermined and œdematous ; the skin around is dark purple in colour. Often important organs, *e.g.*, the penis, will completely slough away.

Considerable pyrexia is present as a rule.

(2) *Chronic ulcerations*, on the other hand, are slow in their formation —the ulceration may progress for years and show no tendency to heal ; there is little tendency to involve the deeper tissues until the later stages, although in the long run the blood-vessels, nerves, periosteum, or bone may be implicated. They usually become fixed to underlying tissues and exhibit the characters of unhealthy ulcers, usually having undermined edges with a base of fibrous tissue sparsely covered with fine granulations. The tissues around are congested, eczematous, and together with the ulcer may show malignant changes, and thus form a menace to the affected person.

The extent of a chronic ulcer is also of importance, for should it surround the greater part of the circumference of a limb the lymphatic vessels of the distal tissues will be obstructed, œdema or even elephantiasis resulting.

The results of healing of a chronic ulcer may be formidable if in the region of joints, the cicatrices producing contractures.

## Varieties of Ulceration.

**Ulcers due to interference with the venous return : (varicose ulcers).**—These are the commonest form of crural ulcer and, as the name implies, are associated with a varicose condition of the superficial veins of the leg. They occur in elderly women of the poorer classes, and are almost invariably situated on the anterior aspect of the lower third of the limb.

Their formation is dependent on several factors. The subcutaneous tissues become chronically inflamed and œdematous as a result of interference with the blood return in the dilated vessels ; the skin over the area becomes eczematous and a brown-purplish colour. A slight injury leads to the formation of a superficial abrasion, which, owing to the condition of the parts, refuses to heal. The ulcer may originate in a septic thrombosis of a varicose vein, an abscess forming which ruptures through the skin and is a starting point of the ulcer. Want of cleanliness, and neglect, aided by infection with micro-organisms, allow the inflammatory process to spread, with the result that an ulcer of the chronic type is formed and persists.

The condition tends to spread round the limb until the whole circumference is involved. Usually the ulcers are single. When healed a pigmented scar is formed.

**Ulcers due to interference with the arterial supply** are exemplified in those occurring in the stomach, where it is suggested that the origin depends on a thrombosis in the smaller arteries. Similar results may be seen on the extremities of the limbs as the result of arterio-sclerosis (see *Gangrene*).

**Ulcers due to interference with nerve supply (trophic ulcers).**—These are most often seen in connexion with some form of peripheral neuritis or spinal lesion ; tabes dorsalis, spina bifida, syringomyelia, chronic anterior poliomyelitis, and sometimes diabetes are amongst the commoner causes. It is thought that the loss of nerve conduction is the primary factor which upsets the vaso-motor control ; possibly pressure or other form of trauma has an influence on the origin of the lesion. In some instances they arise from trauma, such as burns through inability to appreciate heat, as in syringomyelia. The ulcers may occur on the back of persons who are bedridden, but are more commonly seen on the extremities.

Usually a thickening or callosity of the skin is formed, on the surface of which an indolent ulcer appears. The centre of the ulcer frequently becomes depressed until it forms a sinus passing into the underlying tissues, *e.g.*, bones or joints, producing the appearance of punched-out indurated walls. The ulcer is painless as a rule ; there is very little discharge. Necrosis of the bones frequently occurs. It is spoken of as a *perforating ulcer*, and is most typically seen on the under-surface of the metatarso-phalangeal joint of the great toe in tabes dorsalis.

**Ulcers due to pressure.**—This form of ulceration is commonly caused by the pressure of plasters, decubitus, innocent tumours, gouty tophi, and the like.

*Bedsores.*—This form of ulceration occurs in those who are enfeebled by a long illness, *e.g.*, typhoid fever, and whose tissues lack nourishment. The ulcers form over the bony prominences—*e.g.*, the sacrum, spine, trochanters, anterior superior spines, heel and elbow, etc.

Pressure is the cause in the majority of cases, but these ulcers may appear in very thin persons by stretching of the skin over the protruding bone. Pressure is as a rule associated with other factors—*e.g.*, want of cleanliness (saturation with urine or fæces) and consequent bacterial infection, friction, deficient blood supply, loss of fatty tissues, and sometimes the loss of nerve supply, as in myelitis and other spinal lesions. In most cases they are produced slowly. The skin becomes white, purple or even black, and is surrounded by a localised area of induration and œdema.

Infection occurs as the ulcer forms, the base being covered by a slough ; when this is removed an unhealthy chronic ulcer with undermined, œdematous edges remains, from which a profuse purulent discharge exudes. Although most bedsores are superficial, the bones underlying the ulcer may be exposed.

In size the ulcers may be small, but unless rigid precautions are taken they spread extensively. Infection of the spinal meninges from a large sacral bedsore is of frequent occurrence. If the patient recovers, scars form often leading to deformities.

The sores due to pressure by splints, plasters, tumours, and gouty tophi have similar characters, but are rarely so serious in nature or so extensive, being usually seen in tissues which are otherwise healthy.

**Ulcers due to specific micro-organisms.**— 1. *Due to pyogenic bacteria.*—Ulceration of the mouth (ulcerative stomatitis), of the rectum (septic ulceration), bladder (cystitis), and skin may be exemplified as belonging to this class. There are no forms of ulceration which can be said to be characteristically due to pyogenic bacteria, but the latter play a very important part in all ulceration as secondary agents of infection.

2. *Due to tubercle bacillus.*—These have their origin either by direct infection through a wound or as a secondary spread from a tuberculous lesion in a neighbouring organ.

They appear either on the skin or mucous membrane. In the former situation they may arise by direct infection through a wound with the production of a node, which subsequently breaks down to form an ulcer. They are usually seen in debilitated persons. More commonly they are the result of the rupture of a tuberculous abscess, *e.g.*, in the neck in connexion with tuberculous disease of lymphatic glands, in the thigh in cases of hip disease or spinal disease, or around the tarsus or ankle joint.

The ulcers are typically unhealthy, and are prone not to heal until the primary focus has been removed ; when they do scars drawn in towards the focus are formed.

Inflammation of the mucous membrane may be of tuberculous origin and is seen in the alimentary tract in the region of the Peyer's patches as a primary focus of infection ; on the tongue in the late stages of pulmonary and laryngeal tuberculosis ; and occasionally in the rectum, associated with anal fistulæ ; rarely as a primary focus in the bladder, a site in which the ulcers are more commonly secondary to renal tuberculosis.

The ulcers start as small tubercles which fuse together and break down, leaving a shallow ulcer covered by pale, exuberant granulation tissue, with undermined edges and no induration around ; as a rule, they are exquisitely painful. The presence of other tuberculous lesions, the isolation of the bacillus, and other pathological investigations (*e.g.*, inoculation of granulation tissue into a guinea-pig, or section of snipping from ulcer) confirm the diagnosis.

3. *Due to spirochæta pallida* (*syphilis*).—Ulcers due to syphilis may occur in any of the three stages.

In the primary stage ulcers occur either on the skin or mucosa. There is a definite incubation period of from three to six weeks from the time of infection. The lesions may be divided into two groups, those situated on the genitals—*e.g.*, penis, labia, or cervix uteri—and those placed in extragenital sites—*e.g.*, lip, eyelid, tongue, fauces, mamma, skin, nipple, anal margin. The lesion is called a *hard chancre*. It starts as a small painful papule, which enlarges into a hard raised nodule with a flattened surface which subsequently ulcerates. The edges of the ulcer are almost as hard as cartilage. There is no infiltration of the surrounding tissues. The diagnosis can be confirmed by the demonstration of the spirochæte in the exudate from the lesion, or in blood obtained by pricking the edges of the ulcer. It is associated with enlargement of neighbouring lymphatic nodes, which show no tendency to suppuration.

Secondary ulcerations are most commonly seen in connexion with the mucosa of the mouth, fauces, nose, or anus ; they are superficial, small, circular, with clean-cut edges and dusky red bases, running together to form crescentic or serpiginous ulcers. The spirochæte can always be found in these lesions.

The tertiary ulceration results from the breaking down of a gumma. As a consequence of this necrosis a gummy material is discharged, leaving an

ulcer with deep excavated base covered with a slough resembling wash-leather; as this dries a scab is formed, often in layers having the appearance of a limpet shell; such is called *rupia*. The edges of the ulcers are clean cut; there is some induration around. When the ulcer heals it leaves a circular or stellate scar, white or pigmented in colour. The spirochæte is but rarely found on examination. The commoner sites for these ulcers to appear are on the skin of the outer side of the leg just below the knee-joint, on the buttocks, on the neck over the sterno-mastoid muscle, on the scalp, tongue, soft and hard palate, pharynx, larynx, and nasal septum.

4. *Due to bacillus mallei* (*glanders*).—Direct infection by the bacillus is essential. Most commonly the ulcers are seen on the nasal septum as the result of necrosis of apple jelly-like nodules occurring in that situation. The ulcers are small, unhealthy, exuding foul blood-stained discharge.

As they occur on the skin chiefly of the exposed parts, they are found to have shelving and undermined edges; the base burrows into the deeper tissues and may even involve the underlying bones. The lymphatic glands are considerably enlarged in this condition. The demonstration of the bacillus is difficult.

5. *Due to actinomyces*.—Most frequently seen in connexion with the jaws as chronic ulcerative processes occurring around the mouths of the multiple sinuses, from which pus exudes containing granules typical of the condition.

**Ulcers due to growths.**—Innocent growths but rarely give rise to ulcerative processes except by pressure as above described; malignant growths, chiefly carcinomata and more rarely sarcomata, on the other hand, are very prone to do so.

Carcinomatous ulcers may arise in one of two ways—(1) as primary conditions of the skin or mucous membrane; (2) as the result of infiltration of the superficial tissues from a growth lying in the deeper structures.

In many parts of the body certain well-known "precancerous" conditions are found preceding the formation of a malignant ulcer, and amongst these may be mentioned any form of chronic ulceration, including fissures, warts, leukoplakial patches, scars, and the orifices of persistent sinuses.

The ulcers as a rule have hard, raised edges, rolled outwards or everted; the base is hard, warty, or fungating in the form of a cauliflower-like mass; overlying the cells of the growth is a layer of granulation tissue. The base of the ulcer is fixed to the deeper structures and can often be felt infiltrating into the depths. The presence of such, combined with evidence of dissemination to other parts, *e.g.*, the lymphatic glands or viscera, confirms the diagnosis, which may be clinched by histological examination of the edge of the ulcer.

*Rodent ulcer*.—This is a term applied to an epithelial new growth arising in connexion with sebaceous glands, which tends, during the process of ulceration, to eat into the deeper tissues. It starts as a single, small, painless, pinkish-coloured nodule in the skin, which subsequently, often after many months, forms an ulcer having slightly-raised but not everted edges, and a shallow base. The surrounding skin is unaffected. The base often becomes covered with a scab. The ulcer is very chronic and shows a tendency to heal spontaneously at one point and spread at another. It gradually eats into the tissues and often destroys the bone or cartilage lying beneath it. Sometimes the ulcer involves very large areas of tissue. It never gives rise to metastases, and is only locally malignant. The commonest sites for it to be found are at the inner or outer canthus of the eye, scalp, or neck. It is seldom seen below the shoulders. Histologically it has a characteristic structure,

and thus the diagnosis can be readily confirmed. It is usually found in elderly persons.

**Treatment of ulcers.**—1. *Prophylaxis* especially applies to those conditions in which pressure or trauma is likely to cause ulceration. Great care must be exercised in all cases requiring the application of splints or plaster—*e.g.*, fractures, bony prominences under plaster jackets, and ill-fitting shoes.

Especial care should be taken in elderly persons who are bedridden to avoid the appearance of bedsores. Efficient nursing is of primary importance in these cases, but it is the duty of the practitioner to attend to the details of treatment himself. Absolute cleanliness is essential—frequent washing of the skin with soap and water, with due attention to drying subsequently; this may be aided by the application of methylated spirit or lead lotion. If the patient is passing fæces and urine incontinently, special care is required; the mattress should be firm, the sheets drawn tight, and no crease or seam left under the patient. Air-pillows are also useful, and in some cases air-beds are requisite. All foreign bodies, *e.g.*, crumbs, should be frequently removed from the bed. It is not always possible to prevent the appearance of a bedsore, but every attempt should be made to avoid it.

The removal of all sources of irritation—*e.g.*, foreign bodies, jagged teeth, etc.—is required when ulcerative processes depend on their presence.

In cases of obstruction to the intestine or urinary tract with ulceration the division of a stricture or removal of a foreign body should be carried out.

2. When an ulcer has already formed attempts to get it healed should be made in two directions—firstly to remove any obvious cause of the lesion, and secondly to treat the local conditions in such a way that it is possible for healing to occur.

*Specific methods of treatment.*—Under this heading is included the use of drugs—*e.g.*, mercury and potassium iodide for syphilitic ulcerations, potassium iodide for actinomycosis, tuberculin for tuberculous lesions and other forms of vaccine for lesions due to pyogenic micro-organisms, serum for diphtheritic ulcerations, and so forth. It also includes the use of general stimulants in debilitated persons.

The removal of foreign bodies, the extraction of teeth, and the excision of necrosed portions of bone at the base of an ulcer are indicated when they constitute a factor in the failure of an ulcer to heal. The ligature of varicose veins in cases of crural ulcer due to them is sometimes called for, but it must be remembered that sepsis is likely to occur, and great care is required in carrying out the operation.

*Local treatment of ulcers.*—Acute ulcerations for the most part require to be cleansed and dealt with by the application of mild antiseptic lotions. They show a general tendency to heal.

In phagedenic ulcerations the patient should be placed under an anæsthetic and the sloughs removed either by scissors, scraping, or cautery. The base and edges of the ulcer should be painted with pure carbolic acid or seared with the actual cautery. Carbolic acid has the advantage of acting as a local anæsthetic. Dry dressings are applied. Subsequent dressing depends on the condition found; antiseptic dressings, fomentations, baths or dressings soaked in normal horse serum each have their advantage.

*In the case of chronic ulcers* cleanliness is of primary importance; soap and water should be freely used, and all the hair in the immediate neighbourhood removed.

For the removal of scabs, sloughs, and purulent discharge the use of hot baths is advocated; mild antiseptics such as iodine (℥j. ad ℭj.) or Sanitas

(℥j. ad ⊙j.) may be added. Dry dressings should be applied in the intervals. Fomentations serve a similar purpose. Flavine or salt packs are good.

*Absolute rest* is an essential for the speedy healing of all ulcerative conditions. For preference the patient should be in bed. When this is not possible some support should be given to the affected part—*e.g.*, by splints, by the application of Unna's paste, by the use of crutches, by bandaging or strapping with narrow overlapping strips of adhesive plaster. The results, however, will not be so satisfactory. Gastro-enterostomy has a similar object in view when performed in cases of chronic gastric and duodenal ulceration.

Attempts should be made to *improve the blood supply* of the part. Elevation as a means of aiding the venous and lymphatic return is a method easy of application. Daily massage of the area around the ulcer should be tried, and continued for a period after healing has occurred in order to obtain a supple scar and to effect a return of the tissues to a normal condition, thus preventing recurrence of the ulceration.

The *granulations* must be brought into a healthy condition. If fungating, antiseptic lotions and caustics should be applied. Enzymol and ung. sorbefaciens are excellent remedies. The local application of normal horse serum is also efficacious but expensive. If œdematous they should be rubbed with a stick of silver nitrate or copper sulphate ; a mild solution of zinc sulphate (lotio rubra) has a similar effect. Oxygen sprayed on to the ulcer meets with success. When the granulations have been brought into a healthy condition, mild soothing ointments with a basis of sterile vaseline, parolein or lanoline should be applied in order to prevent the removal of young epithelial cells which are growing over the surface of the granulations.

*Operative procedures.*—1. *Scraping* is carried out by the use of a Volkmann's spoon in conditions where large sloughs or exuberant granulations are present, or in chronic ulcerations in order to stimulate the formation of healthy granulations.

2. *Excision.*—Small chronic ulcers in an accessible situation which do not respond to the ordinary methods of treatment should be excised ; also those which are notoriously known to be precancerous or cancerous conditions—*e.g.*, dental ulcers, rodent ulcers, etc. If the ulcer has been completely excised, and the tissues can be rendered aseptic, the wound may be sutured.

3. *Amputation.*—This is called for in the more advanced forms of ulceration owing to (*a*) the extent of surface involved, (*b*) recurrent or persistent attacks of hæmorrhage, (*c*) involvement of lymphatics and resultant œdema (elephantiasis), or (*d*) malignant disease supervening.

4. *Stretching or division of nerves* is called for when pain is a prominent symptom.

5. *The application of X-rays, radium, other forms of rays, or ionisation* are methods which often meet with successful results when others have failed. This applies especially to rodent ulcers, but they are equally useful in other forms.

6. *Skin grafting.*—Some method of supplying normal skin tissues to the surface of a healing ulcer may be introduced in order to hasten the healing process.

7. Scars formed as the result of the healing process may require to be dealt with by surgical measures.

**Skin grafting.**—Skin grafting may be carried out by one of three methods—Thiersch's method, Reverdin's method or a plastic method.

*Thiersch's method.*—The surface of the granulations should be in such a condition that they are smooth and just oozing, quite flush with the surface of the surrounding skin tissues, and bright red in colour.

Antiseptics are usually contra-indicated, but should they have been used the ulcer should be thoroughly washed with saline solution as a preliminary to the grafting. The patient is placed under an anæsthetic. The object of the treatment is to remove small epidermal sections of healthy skin and to place them on to the granulating surface. One of the best sites to select is the inner side of the thigh, which is moderately free from hair; should hair be present the skin should be previously shaved, thoroughly cleansed with soap and water, subsequently with ether, and lastly washed with saline solution.

A special broad-bladed razor known as Thiersch's knife is used. It is well wetted with saline solution, and a shaving of the epidermis, so thin that it will form into folds on the upper surface of the knife, is cut by short drawing movements. This is then cut off and transplanted to the ulcer from the surface of the razor. One end is held down to the skin edge whilst with a probe the shaving is manipulated on to the surface and spread out as smoothly as possible. Air bubbles, should they appear underneath the skin, should be removed by means of a pipette. The points to be remembered in carrying out this operation are :—

1. To stretch the skin before cutting.
2. To have the section so thin that on removal only the tops of the papillæ can be seen, as recognised by bleeding points.
3. The section should be kept moist all the time.
4. All air bubbles should be removed.
5. The epidermal sections should overlap the margins of the ulcer and each other.

The sections having been gently pressed down on to the granulations, a piece of oiled-silk is then laid over the surface; a sterile gauze is laid over the top of this and a bandage applied. Some surgeons prefer to cover the wound with a cage and expose it to the air without the application of dressings. The wound is dressed on the sixth day, the dressings being replaced by a piece of gauze soaked in liquid paraffin. No antiseptics should be used in carrying out this operation.

The epidermal cells will soon cover over the ulcer, leaving behind a smooth supple scar which does not lead to contracture. The surface from which the grafts have been obtained should be dressed in a similar manner.

*Reverdin's method.*—This is an older method, and consists in the application of the whole of the skin thickness instead of the epidermal layer only. The skin may be obtained from some situation where it is loose—*e.g.*, the abdominal wall—from a recently-amputated leg, or from the prepuce in cases of circumcision. It is important that no subcutaneous fat should be left attached to the flap on its under-surface.

A graft of this kind shrinks markedly, and it must be laid down without any tension, otherwise it will not survive. Frog's skin has been used in a similar way, but is quite valueless.

*Plastic operations.*—These are used in special situations—*e.g.*, in the making of a new nose, or in covering over the breast by partially detaching portions of skin where it is not essential and twisting it round, attaching its edges over the area. A flap of skin from some other part of the body, which can be easily sewn to the edges of the diseased area and kept in position for some days, may also be utilised (pedicle graft).

Special methods of treatment are required for ulcers in various situations of the body and will be dealt with under their special headings, but in the main the principles mentioned above will be found to hold good.

## Gangrene.

*Gangrene* is the term used to denote the death of tissues *en masse*. It is usually applied to the superficial structures, especially those of the extremities. Synonymous terms are *sphacelation*, *mortification*, *necrosis* and *sloughing*. Necrosis is more often applied to the death of the internal tissues. The dead tissues, when separated, are called *sloughs ;* in the case of bones, *sequestra*.

*Causation.*—Gangrene is always dependent on the partial or complete obliteration of the blood flow to the tissues affected. The causes may be divided and subdivided as follows :—

A. **Non-infective causes.**—(*a*) *Constitutional.*—Any condition which tends to impair the general blood circulation, and thus bring about a lowering of the resistance of the tissues, must be regarded as a predisposing cause—*e.g.*, diabetes, chronic Bright's disease, senility and anæmia, especially that resulting from a severe hæmorrhage.

(*b*) *Local.*—1. *Direct trauma—e.g.*, crushes, burns and scalds, pressure, chemicals, strangulations (peritoneal bands, hernia, etc.).

2. *Interference with the main arterial supply or venous return—e.g.*, rupture, ligature, embolus, thrombosis, pressure.

3. *Obstruction to the smaller arteries—e.g.*, arterio-sclerosis, endarteritis obliterans.

4. *Spasms or paralyses of arterioles—e.g.*, cold, frost-bite, ergotism, Raynaud's disease, carbolic acid.

B. **Infective causes.**—Many bacteria are responsible for gangrenous conditions which have definite characteristic appearances and groupings. At the same time they are frequently present as secondary agents of infection in many of the conditions in the non-infective group.

The more common forms of gangrene having specific characters are carbuncles, furuncles, Vincent's angina, Ludwig's angina, cancrum oris, malignant œdema, acute spreading traumatic gangrene, hospital gangrene.

**Clinical conditions.**—Certain cardinal signs of gangrene are recognised in all types of lesion irrespective of the cause of the condition ; the absence of pulsation in the part affected, pale, purple or black coloration, the feeling of cold, the loss of sensation and of function, are among the most prominent.

Apart from these, certain other characteristics have led to the clinical distinction of two main varieties of gangrene—the *moist* and the *dry ;* which of these two varieties is likely to occur as the result of any of the above causes depends on (1) the presence or absence of micro-organisms, and (2) the condition of the vessels passing to and from the affected area.

A *sudden* stoppage in the arterial flow to the tissues is responsible almost invariably for the moist type of gangrene, owing to the absence of a *vis a tergo*, which is necessary for the driving of the blood contained in the tissues into the venous channels ; the likelihood of this occurrence is markedly increased if at the same time there is an interference with the flow of blood through the veins themselves ; an excellent example of such is seen in the implication of the popliteal vein in a case of popliteal aneurysm. This is spoken of as *aseptic moist gangrene*, in contradistinction to the septic variety, in which pyogenic and putrefactive bacteria are either the primary cause or agents of secondary infection. The latter is the type more commonly seen.

Dry gangrene is the result of a *gradual* obliteration of the blood-stream in arterio-sclerosis ; under these conditions the venous and lymphatic channels accustom themselves to return the fluids from the affected parts and efficient drainage follows, which, aided by evaporation from the surface, leaves the part

in a dry condition. If microbic infection becomes superimposed the moist variety results.

*Dry gangrene.*—The early symptoms of this condition are tingling and numbness of the skin, often accompanied by severe pain, presumably due to the involvement of the nerves.

The chief changes, apart from the cardinal signs, are to be seen in the alteration of colour of the skin, which, at first white or marbled due to the extravasation of blood along the course of the veins, later becomes olive green and eventually quite black. Resulting from the process of desiccation, the skin shrivels, and the whole of the affected area becomes hard and horny. A peculiar musty smell associated with mummification is frequently noticed. When incised the tissues are found to be quite bloodless. This type of gangrene is most commonly seen at the extremities and is slow in its production and progress.

*Septic moist gangrene* is rapid in its onset and spread. Immediately preceding the cessation of the blood flow the parts are found to be red, hot and painful; depending on the presence or absence of an efficient venous return, after the obstruction takes place and the cardinal signs make their appearance, the skin becomes white or purple, often mottled, bullæ appear on the surface, which is moist and liquefying, and green areas are formed which can be removed readily, exposing the underlying tissues; the whole limb is swollen as the result of extravasated blood and the products of putrefaction; if gas-forming micro-organisms are present, as they frequently are, interstitial emphysema will be recognised by the curious crackling sensation that can be demonstrated by pressure of the finger on the part. The whole limb has a foul-smelling odour even in the early stages. Eventually the skin will slough off, exposing the muscles, which are in a similar condition of putrefaction and liquefaction.

This is the more common form of moist gangrene and is due to bacterial invasion, resulting in destruction of the cell protoplasm and rapid thrombosis of the vessels, both arterial and venous. Putrefactive bacteria bring about the terminal result of decomposition.

*Aseptic moist gangrene* is a less common condition, but due to similar causes, with the exception that bacteria are not present. If an attempt is made to improve the venous return from the parts, the limb may recover or become converted into the dry variety. The production of a collateral circulation is essential for this result. The clinical aspect of the case is similar to that seen in the early stage of the septic variety; the skin becomes pale and anæmic if the venous return is only partially interfered with, but bluish-purple if the obstruction is complete; bullæ form on the skin, which has a curious moist, waxy appearance. When the process has come to an end, the limb which has become swollen remains in a stationary condition until separation occurs, provided that microbic infection does not supervene.

*Separation of the dead tissues.*—The separation of the dead from the living tissues takes place at a point spoken of as the *line of demarcation*. The dead tissue acts as a foreign body, so that at its junction with the living tissues an inflammatory zone occurs. Microbic infection is invariably present at this point, and suppuration, pustulation, and ulceration supervene at the expense of the living tissue, producing a furrow. This furrow extends deeply through the underlying muscles and, in the case of a limb, down to the bone, which, with the exception of its periosteum, is not involved until a much later date than the rest of the tissues; moreover, the bone is involved at a more distal point, giving a conical appearance to the stump that is left. Hæmorrhage very seldom takes place during this process owing to thrombosis of the

vessels. The limb, except that it is attached to the living structures by the bone, thus becomes spontaneously amputated.

In the case of dry gangrene the inflammatory process at the line of demarcation is not very well marked, and is especially ill defined and variable in the early stages. This, as a rule, is due to the progressive nature of the primary factor causing the gangrene. The process is slow and may extend over a period of many months.

The inflammatory zone is most marked in the separation of the tissues in the septic form of moist gangrene; the parts being actively inflamed, the ulceration is deeper and more rapid in its production, seldom extending over a longer period than a fortnight; moreover, the suppuration does not remain localised to the line of demarcation, but tends to spread upwards in the subcutaneous, intermuscular, and periosteal planes, producing a spreading cellulitis.

In the aseptic form of moist gangrene the process of separation shows characters intermediate between these two.

*Constitutional effects.*—The general effects of gangrene are variable. In the early stages of dry gangrene and aseptic moist gangrene very few constitutional signs are present, but as the condition advances pain, sleeplessness, and toxæmia make themselves evident, especially in the former condition, which is most commonly seen in elderly persons. In dry gangrene a transient form of glycosuria is frequently present, and must be distinguished from the diabetic form by the absence of the other signs of the latter condition.

The general symptoms of septic gangrene are very severe and are those of other acute infective conditions, advancing to toxæmia, septicæmia, and pyæmia.

**General treatment of gangrene.**—In the majority of cases the patient should be in bed, under good hygienic surroundings, having a nourishing diet, with stimulants. Sedatives may be required for the relief of pain.

*Local treatment.*—Prophylaxis plays an important part in cases in which the onset of gangrene is threatened. Warmth should be applied by wrapping cotton-wool around the part, aided by the use of a hot-water bottle, care being taken not to inflict a burn; the part should be kept as dry as possible. Gentle massage and elevation of the limb tend to stimulate the return of the blood and exudate from the tissues. Electric baths are often of much service. If fluid increases in the tissues, incisions for its removal are requisite.

When gangrene has commenced—

(*a*) The cause of the condition often demands surgical interference, *e.g.*, the removal of an embolus, the division of bands causing gangrene of the bowel, the avoidance of ergot and carbolic acid, etc.

(*b*) The prevention of septic infection calls for urgent attention; the part should be thoroughly cleansed with soap and water, all hair should be shaved off, and sterile dressings and coverings subsequently applied.

(*c*) Attempts must be made to encourage the resolution of a moist gangrene into the dry form, as this is a less serious condition.

(*d*) If the dry form of gangrene is present, or moist gangrene which is not progressing rapidly or causing marked constitutional disturbance, await the formation of a line of demarcation.

(*e*) If moist gangrene of the above type is present, aid the removal of sloughs by using moist heat in the form of fomentations, hot baths, or even local excision of gangrenous tissue; at the same time treat the sepsis.

(*f*) After the sloughs have been removed the condition must be treated as an ulcer.

(*g*) Amputation is called for when marked evidence of toxæmia, septicæmia, or pyæmia appears. In the more chronic forms the formation of a line of demarcation is the indication for amputation of a limb, or local excision if other areas are involved. In cases of moist gangrene which are spreading rapidly, even if constitutional disturbance is not very serious, early removal is indicated. The level at which the amputation should be performed is such that infection of the flaps is not likely to take place.

In the dry form always wait for the line of demarcation to form unless toxic absorption, especially in elderly persons, demands otherwise. Again, the amputation should be carried out sufficiently high up to prevent the flaps sloughing for want of an efficient blood supply.

**Special varieties of gangrene.—Gangrene due to trauma.**—This may result immediately after an injury has occurred—for example, a limb may be crushed by a heavy weight; such is spoken of as *direct trauma*. Other causes in this group are burns, scalds, pressure, strangulations by bands, etc.

1. *Direct trauma.* Gangrene may arise in one of two ways—either by immediate death of the tissues at the site of the injury, as occurs in crushes, or at a later stage as the result of an injury to the vessels and nerves supplying the area affected.

In the first group all the tissues of a limb may be involved in the injury and only attached to the body by the skin or blood-vessels. In the second group the external evidence of injury may be slight although the vessels may be completely severed. Extravasation of blood into the tissues is often considerable, and may so distend them as to play an important part in the process of destruction. The gangrenous process is invariably of the moist type, owing to secondary bacterial infection.

*Treatment.*—The guiding principle in the treatment of all injuries is to save as much of the tissues as possible, especially if it happens to be a limb that is affected. This is particularly essential in the case of young persons having to earn their own livelihood. Youthful patients are more likely to recover from such injuries.

The shock should first receive attention. The injured part should be put at rest in such a position as will encourage the return of blood; all bleeding points having been ligatured, the part should be cleansed thoroughly with soap and water and antiseptics; if necessary an anæsthetic should be given, unless the condition of shock contra-indicates its use.

The part should be dressed with aseptic dressings; if gangrene supervenes the principles indicated above should be adopted. If there is a likelihood of anaerobic bacteria having infected the wound, as in the case of street accidents, frequent baths in alkaline solutions of hydrogen peroxide are desirable.

The surgical excision of the affected area, or amputation in the case of a limb, is indicated in those cases in which from the nature of the injury the onset of gangrene is inevitable, *e.g.* (*a*) if the limb is a mere pulp; (*b*) if the main artery is torn and it is unlikely that a collateral circulation will save the part; (*c*) if all the structures of a limb are torn across except the bone, or if only hanging on by skin and a few muscle fibres.

Secondary removal or amputation is indicated (*a*) if moist septic gangrene, malignant œdema, acute spreading gangrene, or tetanus supervenes; (*b*) if moist or dry gangrene of considerable areas follows at a later stage with the formation of a line of demarcation; (*c*) if the limb becomes so deformed at a later stage as the result of the gangrenous affection as to be rendered unserviceable.

No operation should be performed while the patient is in a condition of severe shock.

2. *Burns and scalds.*—A burn is a destruction of tissue due to the application of dry heat.

A scald is a similar condition due to the action of moist heat.

The resultant effect of these two conditions is the same, except that the lesion is likely to involve a larger area of tissue if due to fluid.

The effects may be shortly summarised, as first described by Dupuytren, according to the depth of tissues which becomes involved :—

*First degree.*—Simple erythema, with desquamation of the surface cells ; the condition recovers without leaving a scar.

*Second degree.*—Vesiculation, due to exudation taking place from the surface vessels in amongst the epithelial cells and producing a blister ; this heals without leaving a scar, but often the skin is pigmented for some time.

*Third degree.*—Destruction of the superficial skin tissues down to the level of the papillæ without involving the hair follicles, sweat glands, or sebaceous glands. The sensory nerve endings are involved in this stage; hence the condition is very painful. A scar will form.

*Fourth degree.*—Involvement of the whole of the epidermis and true dermis down to the superficial fascial layer. This leads to the formation of sloughs, which later separate, leaving granulating areas ; these subsequently form scar tissue, contractures and resultant deformities.

*Fifth degree.*—Destruction of skin and fasciæ and involvement of the muscles, etc.

*Sixth degree.*—Complete charring of the affected tissues.

Many of these stages may be combined in a single burnt area ; moreover, it is often impossible in the early stages to state accurately which of the various degrees is present ; a burn which may appear to be of the third degree, for example, may subsequently turn out to be of the fourth, and so on.

In the early stages microbic infection does not obviously take place, but it is exceedingly prone to supervene and be responsible for the serious results which frequently follow.

After recovery bad deformities may ensue as the result of cicatrisation.

*Constitutional effects.*—The effects of a burn or scald depend on the extent, depth, position, and age of the patient.

A burn is more serious when it involves a large superficial area than when it is localised but deeply involving the tissues. A burn on the trunk and head is more serious than one affecting the extremities. Burns in old people and young children have much more serious effects than those occurring in healthy adults. The effects may be divided into three stages :—

(*a*) *Shock.*—The symptoms of shock and collapse in a burn of any considerable extent are often very severe, the patient passing into a stage of coma, and death may ensue within a few hours. The pulse becomes small, frequent and fluttering ; the temperature subnormal ; the skin cold and clammy ; the eyes sunken and lustreless. This stage rarely lasts more than twenty-four hours, and is the most frequent cause of death from burns or scalds.

(*b*) *Reaction* follows the survival of this stage in twenty-four to forty-eight hours ; the temperature rises ; the pulse becomes fuller, but still beats rapidly ; the patient sweats, and fever continues. The lesion shows the signs of inflammation, and if death occurs during this stage, as it

frequently does, bacteria will be found in the heart's blood. This is a very dangerous stage of a burn, owing to this liability to toxæmia and bacteriæmia. Broncho-pneumonia is not uncommonly found in children. Albuminuria is often present, due to toxic effects on the cellular tissues of the kidneys.

(*c*) *Stage of suppuration.*—The constitutional effects during this stage are dependent on suppuration in the lesion and are the same as those occurring in other suppurative conditions. Secondary hæmorrhage is liable to take place during the separation of the sloughs.

Death may occur, therefore, in any of these stages—in the first from shock, in the second from toxæmia or bacteriæmia, and in the third from either of these, or even pyæmia or amyloid disease.

*Treatment*—*Constitutional treatment* must receive attention before the local condition is dealt with; this statement of course applies to those cases in which the degree of shock is considerable. An initial warm bath has a two-fold object in counteracting the shock and at the same time soaking off burnt clothing and dirt. Whenever possible a sequence of warm baths serves as an excellent form of treatment, not only during the first stage, but also during the period when septic absorption is liable to occur. The water should be replenished frequently. Apart from this, the patient should be placed in bed between blankets, surrounded by hot-water bottles or some form of electrical heating. Stimulants such as brandy, ether, strychnine, or adrenalin should be administered subcutaneously. The giving of normal saline solution, either into the veins, subcutaneous tissues or rectum, is of great service, and half to one pint inoculations should be frequently used; fluids should be given by the mouth if the patient is able to swallow. The use of small doses of opium for the relief of pain is indicated. A stimulant form of treatment should be continued for some time after the recovery from shock in order to counteract the toxæmia.

*Local treatment* depends to a certain extent on the degree of the burn.

*First and second degrees.*—In the milder forms of burn—that is those including only small areas—the application of some oily substance such as Carron oil (linseed oil, lime-water and a little turpentine) "amberine," or vaseline is very comforting and relieves the pain. Washing of the part, the use of strong antiseptics, and exposure to the air tend to increase the discomfort. Hot baths serve to get rid of superficial dirt; these should be followed by the application of sterile dressings soaked in calamine lotion, sodium bicarbonate solution, or glycerinum plumbi subacetatis dil. The vesicles should be pricked and the dead epithelium around cut away.

A solution of picric acid in alcohol (1 per cent.) painted on the affected area or on lint is a favourite application, as it not only relieves the pain, but also serves as an antiseptic, and in the more advanced forms of burn tends to stimulate the formation of granulation tissue; it should be reapplied every two or three days, and not used in stronger solutions owing to poisonous effects, namely, vomiting, yellow pigmentation of the skin and conjunctivæ, dark colouration of the urine, and yellow vision; the presence of picric acid or its salts can be demonstrated in the urine.

*Third and fourth degrees.*—In the early stages the burn should be treated as above. Later dry sterile dressings and mild antiseptic lotions can be used in cleansing the part. When the sloughs commence to form they should be gradually removed by snipping them from the underlying tissues until the whole of the dead tissue up to the line of demarcation has been removed. The area should then be treated as an ulcer until it is covered with healthy

granulation tissue. Skin grafts should be applied, so as to avoid a bare area, through which septic absorption and its consequent ill results are liable to take place, a disfiguring scar or contracture.

*Fifth and sixth degrees.*—If the patient survives the shock, and the burn is on one of the extremities, primary amputation is usually indicated. In other parts of the body the only lines of treatment are those indicated in the milder forms of burns.

The prevention of scar formation should always be in the mind of the surgeon; when the lesion is in the region of a joint the careful application of splints in such a way as to counteract the tendency to deformity will prevent the formation of bands which will interfere with the use of a limb. By the use of skin grafting less scar tissue is likely to form. If such is not possible, or should it occur after the grafts have been applied, daily massage to prevent adhesion to the deeper structures is indicated. Excision of bands of scar tissue is often necessary.

Other varieties of burns :—

*Sun-burn* is a burn of the first and second degrees, resulting from exposure to the heat of the sun for a length of time. It is usually painful. Freckles (ephelides) frequently result from this condition. Desquamation of the skin takes place in a few days.

*X-ray and radium burns.*—The effects of X-rays manifest themselves in two ways—(1) as a burn resulting from a single exposure to the rays extending over a long period, and (2) a chronic dermatitis in those whose occupation necessitates repeated exposures. The latter are being less frequently met with as the knowledge of how to avoid the condition is recognised.

Similar burns are seen in connexion with radium exposures. These may not appear for some considerable time, even months after the application.

A few days after an exposure the skin becomes pigmented or reddened and is quite painless; on about the tenth day the reddening increases, blebs form, and necrotic areas are produced. In the milder forms healing occurs spontaneously, but in the more severe types chronic ulceration ensues, often extending over a period of one to two years.

Resulting from repeated exposures, a chronic indurative dermatitis is produced, with shedding of the nails and destruction of hair; the formation of gangrenous patches, with subsequent ulceration, necrosis of underlying tissues, and even carcinomatous changes, often supervene. This form of cancer is very slowly progressive, involving the underlying bones of the fingers, a site commonly affected, giving rise to lymphatic involvement and fatal metastases. Sterility from testicular atrophy is sometimes seen.

*Burns due to chemicals—e.g.*, caustic potash, nitric acid, sulphuric acid—do not differ materially from burns due to heat.

**Gangrene due to pressure.**—The use of a tourniquet or tight bandaging over a prolonged period, the strangulation of the intestine by a band or the orifice of a hernial sac, the pressure of a tumour or of a calculus or fæcal concretion in the intestinal tract, are examples of this condition. The sores produced on the back of a bedridden person in a weakly condition, known as *bedsores* and *plaster* or *splint sores* (see under *Ulceration*), are of a similar nature. The condition is due to local pressure on the vascular supply of the affected area. Gangrene of the moist type is the rule. In the treatment of the condition the removal of the cause often leads to complete recovery; if not, removal of the affected tissue may be necessary.

**Gangrene due to interference with the main arterial supply or venous return.**—The causes of this condition comprise rupture, ligature, pressure, embolism, thrombosis.

It is not inevitable that gangrene should supervene on the sudden obstruction of the main vessels to a part, provided that the vessels themselves are in a healthy condition and there is an efficient collateral circulation capable of carrying on the blood supply of the tissues. In certain instances, *e.g.*, the pulmonary artery and the superior mesenteric vessels, there is no collateral circulation, and should any of the above conditions arise in them gangrene is certain to follow.

If the vessel walls are themselves affected as in endarteritis or atheroma, then the liability to gangrene of the tissues supplied by them is increased. Again, when the artery and vein are simultaneously involved it is probable that necrotic changes will result.

Rupture of main vessels occurs in a variety of ways; as the result of an accident, a partial tearing of some of the coats may take place, leading to thrombosis, or the whole vessel wall may be divided, without a lesion of the skin (indirect traumatic gangrene), the blood extravasating into the surrounding tissues and acting as a compressor of the neighbouring vessels; similar results may follow injuries by bullet wounds, sword cuts or tears by the sharp end of a fractured bone. Ligature of a main vessel may be required in order to stop hæmorrhage in the treatment of an aneurysm.

Instances of pressure on main vessels may be exemplified by the proximity of an exostosis at the lower end of the femur to the popliteal vessels, or an aneurysm involving its neighbouring vein.

Thrombosis of an artery is usually dependent on some disease of the vessel wall, *e.g.*, arterio-sclerosis, or an injury. It may result from an enfeebled condition of the circulation, such as is observed during the course of wasting and febrile diseases, *e.g.*, typhoid fever or scarlatina. Venous thrombosis alone seldom gives rise to gangrene.

Emboli most frequently result from endocarditis, vegetations from the heart valve, or blood-clot from the auricle being carried by the blood-stream to a vessel which, on account of its size, will not allow of their passage. Dislodged thrombi from a vein form another source. The bifurcation of a main vessel into its terminal branches is a frequent site for such a blockage to occur; it is usually incomplete at first, but subsequently becomes complete owing to a secondary thrombosis, which may be very extensive and later involve other important vessels, leading to gangrene of other parts. The gangrene resulting from these causes is of the moist variety.

*Symptoms.*—The cardinal symptoms of gangrene rapidly supervene on the interference with the circulation of the parts involved. If a collateral circulation develops, the recovery of the limb follows as a rule within twenty-four hours, or a condition of dry gangrene may result. When the vessels rupture, blood becomes extravasated into the surrounding tissues, giving rise to a brawny induration and swelling of the limb beyond, the skin of which becomes dusky red in colour. The gangrene, which is of the aseptic moist type in the early stages, rapidly becomes infected, and decomposition follows.

In embolic conditions there is a sudden pain at the site of blockage, a point of much importance as indicating the position of the embolus. Unless the embolus is infected, the gangrene is usually of the dry type, the vein being uninvolved.

In thrombosis the process is much slower, and is ushered in by cramps, aching pain in the limb, loss of power, and feeling of coldness until the

characteristic symptoms are present; if the arteries alone are affected, dry gangrene follows, but if the veins are involved the moist variety will be found.

Similar signs to those above mentioned will be found after ligature of the vessels.

*Treatment.*—In dealing with these conditions the general principles of treatment of gangrene mentioned above must be observed.

Certain special points should be mentioned.

If a vessel is torn across, with bleeding into the tissues, it should be ligatured and the blood-clot removed; gangrene may, by timely incision, be avoided.

In the case of embolic gangrene an attempt should be made to remove the embolus, if its situation can be located, by incision of the vessel and subsequent suture (*arteriotomy*). There is a tendency for thrombosis to occur after this procedure has been carried out, which may necessitate amputation at a later stage. Emboli have occasionally been removed from the pulmonary artery. In certain cases a direct end-to-end anastomosis between an artery and a vein has been carried out, but the results have not up to the present been very satisfactory; the chief indication for doing this is in traumatic lesions, where the vessels are not in an unhealthy condition. When amputation is necessary it should be carried out at a level above the lesion in the vessel, unless the collateral circulation below it is well established.

**Gangrene due to obstruction to the smaller arteries.**—This is most frequently due to arterio-sclerosis and affects the arteries of the lower limb.

The gangrene resulting from this condition is most commonly seen in elderly persons, and for that reason is usually called *senile gangrene*. Men are affected more than women. A similar condition, arterio-sclerotic in origin, is recognised in much younger persons, known as *pre-senile* or *spontaneous gangrene* (arteritis obliterans). It differs in no way from the condition seen in elderly people. Arterial changes probably are liable to occur at a much younger age than has been hitherto supposed.

Diabetic gangrene belongs to this class, and differs only from senile gangrene in that glycosuria and the other signs of diabetes are present. The fact that it is seen in diabetes occurring in elderly persons, and not in the type affecting young people, is evidence that it depends on arterial degeneration.

The change takes place in the middle coat of the vessel walls and is of the nature of a calcareous deposit, arranged in a circular fashion around the walls, giving to them a rigid roughened structure; thrombi form, and gangrene follows. There are certain predisposing causes for this vascular change—*e.g.*, chronic Bright's disease, gout, syphilis, alcohol, chronic lead poisoning, and excessive strain resulting from cardiac hypertrophy.

The vessels most frequently affected are the tibials, with resultant gangrene of the toes and foot; but the change occurs in most of the smaller arteries of the body, which become hard and frequently tortuous. Other evidence of arterio-sclerosis will be found, namely, cardiac hypertrophy, albuminuria, high pulse tension, &c.

Preceding the onset of the gangrene the patient will complain of pains and cramps in the legs, tingling, hot and cold sensations and often numbness, relieved by resting the limb and brought on by exercise. The pulse of the posterior tibials and dorsalis pedis becomes imperfectly felt and eventually disappears. The gangrene usually commences in the region of the nail-bed of the great toe as a red, slightly œdematous swelling, which darkens in colour

until it becomes black. As a rule, the condition is one of dry gangrene. A line of demarcation very slowly forms with ulceration around the base of the dead tissue, the process often extending over a period of some months. Occasionally the toe falls off, but more often the condition spreads to the neighbouring toes and also the dorsum of the foot, a fresh line of demarcation being formed from time to time. There is a tendency for moist gangrene to occur unless strict aseptic precautions are observed. Death will eventually result from toxæmia or septicæmia unless some form of treatment is carried out for the removal of the affected tissue. An X-ray picture will demonstrate the presence in the blood vessels of this form of vascular degeneration and also the extent to which they are involved.

In diabetes the gangrene is also of the dry type, but readily tends to become moist, probably due to the liability for microbic infection to occur in cases where glucose is present in the blood.

*Treatment* consists largely in prophylaxis. When the premonitory symptoms make their appearance, an attempt should be made by the use of massage, warm baths, and gentle exercises to assist the circulation. Warm woollen clothing should be worn. Scrupulous cleanliness must be observed. The patient must be cautioned to avoid an injury to the feet, especially the wearing of tight boots, and must not expose his limbs to either excessive heat or cold. Light diet, limitation of alcohol and reduction of glycosuria, which is commonly present apart from diabetes, should be carried out. The avoidance of carbohydrates and the use of opium and codeine are indicated in cases of diabetes.

When the gangrene commences the patient must be put to bed, strict asepsis observed, warmth applied in the form of cotton-wool, and the limb raised in order to assist the return of blood from the part. Opium in small doses should be given for the relief of pain. When a line of demarcation forms the slough or the toe may be allowed to fall off, or may even be cut off if only loosely attached. Frequently the ulcer will heal. On the other hand, if it is spreading rapidly on to the dorsum of the foot or is causing pain and exhaustion, early amputation should be resorted to, especially in elderly persons.

Amputation should be above the knee-joint. The object of this is that in a single large vessel thrombosis is less likely to occur than in the two smaller vessels which provide the blood supply to the portion of the limb that is left should the amputation be performed below the joint. The X-ray appearances of the vessel indicate a suitable site for removal of the limb.

More recently arterio-venous anastomosis, between the femoral artery and vein in Hunter's canal, has been carried out with some success, in that warmth has returned to the limb and the gangrenous process has been limited.

The presence of sugar in the urine should not influence the line of treatment, except that an attempt should be made to reduce its quantity; a failure to reduce it is no indication to avoid operative measures.

**Gangrene due to spasms of arteries.**— 1. *Gangrene due to ergot*—a condition most commonly seen amongst the Tyrolese peasants who live on ergotised rye bread. It is seldom seen in persons who are taking ergot as a drug. The disease is very rarely seen in these days.

The symptoms of ergotism are gastro-intestinal, also dizziness, headache, numbness, chilliness, tingling of the extremities, with frequent muscular spasms; occasionally epileptiform convulsions follow; the toes, fingers, and ears or nose most frequently are affected. It is usually the dry form of gangrene, and symmetrical.

*Treatment* is to avoid the bread and treat according to the principles above indicated.

2. *Gangrene due to frost-bite.*—This is due either (1) to direct action of continued intense cold, resulting in death of tissues, or (2) to indirect action, due to the violent inflammatory reaction which ensues on the restoration of the circulation to the tissues whose vitality has been lowered by previous exposure. It results probably from vascular spasms associated with destruction of cell protoplasm.

It is seldom seen in this country except in severe winters.

The parts most frequently affected are the feet, hands, nose, ears, cheeks, chin and the external genitals.

Three degrees of frost-bite may be mentioned :—

(1) Tingling, numbness, redness, and pain, usually up to the actual loss of sensation ; recovery from this stage is probable if the part is placed under suitable conditions.

(2) Œdema, anæmia, or venous congestion, depending on the amount of

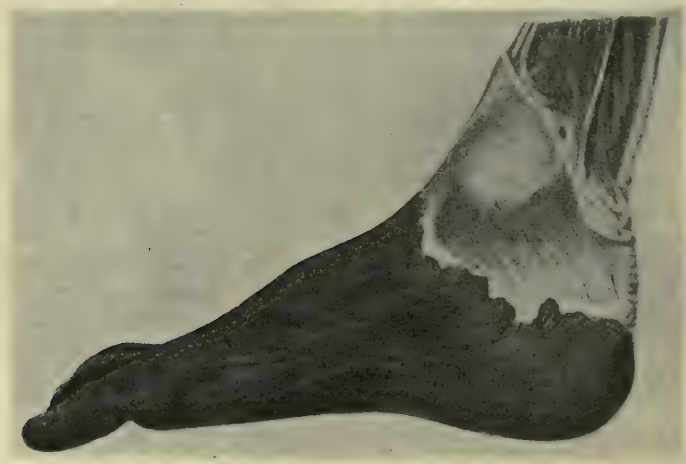


Fig. 1.—Gangrene from frost-bite.
(St. Bartholomew's Hospital Museum.)

blood in the tissues ; vesiculation and sloughing of a localised area of tissue.

(3) In extensive frost-bites dry gangrene of large areas is produced, often involving considerable portions of the whole thickness of the limb.

*Treatment* consists in stimulating a gradual return of the circulation to the affected area, as the more rapid methods tend to produce an excessive inflammatory reaction with thrombosis and death. The use of alcohol is to be avoided. Place the patient in a cold room and gently massage the parts with snow or cold water, and later warm water, gradually increasing the temperature as the parts recover. The method of treatment indicated above should then be instituted. As it is always doubtful as to how much tissue is likely to necrose, a line of demarcation should be seen before amputation is advised.

3. *Chilblains* or *pernio* are localised areas of congestion caused by exposure to cold or damp in persons of feeble circulation. They are most frequently seen on the fingers and toes. They are usually small, well-defined bluish-red

or purple areas, frequently multiple, giving rise to considerable irritation. Ulceration may occur on the surface.

*Treatment* consists in promoting a better circulation by exercise, tonics and good food. Locally woollen gloves or stockings should be used. If ulceration occurs local antiseptics should be applied.

4. *Gangrene due to Raynaud's disease.*—This is a condition of gangrene occurring during the course of Raynaud's disease, which is dependent on some abnormal condition of the vaso-motor centres. The gangrene is only a sign of the condition. It is commonly symmetrical in distribution, affecting the tips of the fingers, the toes, the nose, and the margins of the ears; but one finger or toe only may be involved. It is most often seen in young persons between eighteen and thirty years of age, but may occur in children or older people. Females are more frequently affected than men.

Exciting causes of the necrotic changes are slight injury, cold, and great emotion.

*Local signs.*—Owing to a spasm of the arterioles, the part affected suddenly becomes blanched, cold, insensitive, but painful and shrunken, the stage of *local syncope*. Resulting from a subsequent relaxation of the spasm, the part becomes swollen, hot, painful, and congested, often so much as to become purple or black, the stage of *local asphyxia*.

These alternating changes take place intermittently, and gangrene does not necessarily result for a considerable length of time. Paroxysmal hæmoglobinuria is often associated with the condition, especially when occurring in the cold weather.

FIG. 2.—Gangrene of the finger produced by carbolic acid fomentation.

When gangrene does supervene, only small areas of tissue as a rule become necrotic with blister formation; they have a tendency to heal and leave scars. On the other hand, whole fingers may slough off, the bones frequently being involved. Both the moist and dry forms of gangrene may occur.

Careful investigations of the vascular system should be carried out in order to distinguish the condition from pre-senile gangrene.

The *treatment* in no way differs from that of other forms of gangrene, with the exception that electrical baths are very useful before the gangrene has set in.

5. *Carbolic acid gangrene.*—Strong solutions applied locally cause immediate death of the tissues.

Compresses or fomentations of weak solutions of carbolic acid will produce gangrene, if applied even for short periods of time. It is most commonly seen in the fingers. Lysol, caustic potash, and other chemicals are liable to produce similar effects.

Numbness and tingling are first noticed, followed by complete loss of sensation, the skin turning white in colour, later brown, and eventually black. It is probably due to the local effect of the drug on the tissues, vascular thrombosis and arterial spasm combined.

*Treatment.*—As a rule amputation after the formation of a line of demarcation is the only possible form of treatment.

**Gangrene primarily infective in origin.**—In many cases of infective gangrene the micro-organism responsible for such is known; in others it is still undecided as to which is the causal agent, various observers regarding different bacteria as being responsible for the same condition.

In the first class may be mentioned carbuncles and furuncles due to the staphylococci, Ludwig's angina due to streptococci, cutaneous anthrax due to the anthrax bacillus, œdematous and emphysematous gangrene of the cellular tissues due to specific anaerobic bacteria. Each of these will be dealt with under the headings of these micro-organisms.

In the second class may be mentioned such conditions as cancrum oris, noma vulvæ, hospital gangrene, and Vincent's angina. Although certain bacteria are said to be responsible for each of these conditions, there is some doubt about it, and it is possible that some still undiscovered micro-organism is present, especially as the lesions produced are extremely rapid in their formation, destructive in their action, and productive of profound toxæmias, not usually associated with other forms of bacteria.

*Cancrum oris or gangrenous stomatitis.*—This condition is most commonly found in weakly children recovering from certain of the exanthemata, especially measles, scarlatina, and typhoid fever. It is also seen in adults associated with other forms of stomatitis. A bacillus described by Lingard has been thought to be responsible for the condition, but streptococci and anaerobic bacilli of various types are also found. The lesion commences as an œdema of the mucous membrane and submucous tissues of the cheek, with the rapid formation of an ulcer covered by a greyish-black slough; the whole cheek becomes involved in a brawny swelling with a central white or black area, through which a perforation of the skin subsequently takes place; the discharge from the ulcer is extremely foul-smelling and often blood-stained; later the gums, jaw-bones, and floor of the mouth become involved; secondary hæmorrhage from the facial artery is liable to occur. The destruction of the tissues may be very extensive.

The constitutional symptoms are always severe, a fatal result from toxæmia or broncho-pneumonia being the commonest sequel. If recovery follows, owing to the loss of considerable areas of tissue a scar likely to produce marked deformity is inevitable; false ankylosis of the jaw may result.

*Treatment.*—The removal of the slough is essential. The patient should be given an anæsthetic; the pieces of dead tissue should then be cut away until a bleeding surface is obtained; the area thus exposed should be painted with pure carbolic acid or nitric acid, or, better still, the actual cautery should be applied. If the lesion continues to spread, the treatment may require repetition. Continuous mouth washes of potassium permanganate should be used; packing with iodoform gauze is also useful.

The use of stimulants and opium for the relief of pain is indicated.

During the process of healing the patient should be encouraged to open the mouth widely, owing to the liability to ankylosis of the jaw.

*Noma vulvæ* is a similar condition to cancrum oris, affecting the female genital organs. The clinical characters are similar, and the same line of treatment should be adopted.

*Hospital gangrene or phagedenic gangrene.*- This is a condition not often seen in these days in large hospitals, now that the desirability of surgical cleanliness and the isolation of septic cases is recognised. It used to be frequently met with in overcrowded hospitals, and on ships in time of war before these precautions were observed.

The disease is due to anaerobic bacilli and streptococci. It is contagious, and usually occurs in epidemics. Possibly an undiscovered specific bacterium is also present. There is usually a definite incubation period varying from a few hours to three days.

The disease is characterised by a rapidly destructive, widely-spreading ulceration, covered by a large grey slough supervening on a previously healthy wound ; the discharge is horribly foul-smelling, yellowish-green in colour, and frequently blood-stained ; the surrounding tissues are œdematous, boggy, and livid ; the underlying structures, including the fasciæ and muscles, are converted into a pulpy mass, and secondary hæmorrhage, due to involvement of the vessels, is liable to occur. Marked constitutional disturbance is shown by the onset of pyrexia, delirium, coma, and often death in a short period of time.

*Treatment.*—The same treatment as for cancrum oris should be adopted. In the case of a limb amputation may have to be considered. Precautions to prevent dissemination to other patients must be taken.

*Vincent's angina.*—This is an acute gangrenous condition affecting the tonsils and soft palate, associated with marked constitutional disturbance. A spirillum called after Vincent and a fusiform bacillus are found on examination of film preparations of the discharge.

## DISEASES DUE TO SPECIFIC BACTERIA.

### Staphylococcal Infections.

The *staphylococcus* is responsible for lesions which possess the characters of a localised inflammation. It affects any part of the body, but chiefly the skin and the bones. The staphylococcus is also the commonest micro-organism which secondarily infects lesions due to other bacteria.

Staphylococci normally exist in the skin, the mouth, intestine, and urethra. They are responsible for a very large number of suppurative processes in the body. Their method of ingress is usually through the skin, but occasionally it is difficult to demonstrate how they arrive in the particular organs affected. Among the acute localised lesions which the staphylococcus produces may be mentioned furuncles, carbuncles, subcutaneous abscesses of many kinds and breast abscesses, in all of which the infection has undoubtedly taken place through the skin. These lesions remain localised, but secondary infection of the lymphatic glands which drain the infected area may occur.

Of the generalised infections acute osteomyelitis is the one most commonly met with, the infection probably originating from the tonsil or skin. The lesion, which is of the nature of an acute necrosis, commences in the bone marrow at the epiphyseal end of a long bone, and from this site it is exceedingly prone to set up a bacteriæmic or pyæmic condition with the circulation of the staphylococci in the blood-stream and the formation of metastatic abscesses in such situations as the lungs, the heart muscle, the kidneys, or the serous cavities. Septic arteritis and endocarditis, with their subsequent complications, may also be due to this micro-organism.

Chronic generalised staphylococcal infections are at times seen originating

in a chronic bone abscess, giving rise to similar lesions in other bones and the subcutaneous tissues.

One feature of these infections, whether they be localised or generalised, is their tendency to appear in recurrent attacks.

The recognition of a staphylococcal infection depends on the following factors :—

1. The character of lesions for which it is known to be commonly responsible.
2. The demonstration of the micro-organism.

*Bacteriology.*—Of this micro-organism there are two main types—the *staphylococcus pyogenes aureus* and the *staphylococcus epidermidis albus*. Of the former there is a sub-variety, the *staphylococcus pyogenes albus*, which in all probability is the same micro-organism in a different phase of existence.

Film preparations from a staphylococcal lesion show that the micro-organism is a coccus ·9 $\mu$ in diameter, occurring in pairs or clusters, uniform in size, situated extracellularly, staining with the ordinary aniline dyes and by Gram's method. All forms of the staphylococcus grow quite easily on the ordinary laboratory media.

The differentiation between the *staphylococcus pyogenes aureus* and the *pyogenes albus* is one of colour only. The *staphylococcus epidermidis albus* has to be differentiated by certain bio-chemical tests ; moreover, the former is pathogenic in that it produces localised lesions in animals, *e.g.*, rabbits and guinea-pigs, whereas the latter is non-pathogenic.

*Treatment.*—When an abscess has formed, it should be incised, swabbed out with pure carbolic acid, and dressed with dry sterile gauze. In the conditions which are recurrent the use of vaccines is strongly recommended, for conditions due to this micro-organism respond more readily to vaccines than any other.

**Furunculosis.**—Furunculosis is the condition of multiple boils. *The boil or furuncle* is a circumscribed inflammatory process of the skin and subcutaneous tissue terminating in gangrene of the central part, which, being cast off as a slough, is popularly spoken of as the *core*.

Boils occur in any part of the body, but most frequently on the back of the neck, the face, the buttocks, the armpits, the bearded chin (a condition spoken of as *sycosis*), the eyelids (in ciliary blepharitis or *styes*), as the result of the production of a sore place by the rubbing of a collar or local irritation, as the result of rowing, etc.

They are particularly prone to occur in young people, but may appear at any age of life, and especially in those who are suffering from wasting diseases, diabetes, albuminuria, or some other infective condition which has brought about a secondary anæmia.

The lesion starts in the neighbourhood of hair follicles or sweat glands as a small pimple, which gradually enlarges and becomes surrounded by an area of inflammation which is red, hot, painful, and brawny in appearance. As it increases in size it becomes a dusky purplish red. From this stage the inflammation may subside without going on to a suppurative condition, or remain as an indurated node for some time—this is spoken of as a *blind* boil. More often it softens at the apex or most prominent point ; here a small pustule forms, bursts, and pus exudes, leaving behind a yellow slough which is subsequently discharged. The inflammatory process then subsides, leaving behind a small pigmented scar. The neighbouring lymph nodes are frequently enlarged and painful, and may suppurate. In many cases a single boil is followed by the appearance of a crop, and, even though these may heal, recurrence is frequent, so that the condition must not be regarded too lightly as an insignificant affair.

There are few conditions for which it can be mistaken, for the lesions have a typical appearance. It must be borne in mind, however, that in the early stages of the formation of an anthrax lesion it is possible to mistake the two conditions. The general symptoms associated may be those of anæmia, general malaise, and even fever.

*Treatment.*—The first treatment is that of prophylaxis, which consists in general cleanliness and the avoidance of sources of irritation, such as frayed collars. Occasionally boils can be aborted in the early stages by the application of pure carbolic acid or pure izal on the end of a stick. When the lesions have made their appearance fomentations may be applied to relieve the pain, the part having been thoroughly cleansed with soap and water and the hair in the neighbourhood removed by shaving. This is liable, however, to lead to the formation of a crop of pustules around the original lesion, which should if possible be avoided by keeping the area painted with tincture of iodine.

During the stage of the blind boil a crucial incision will relieve the pain. When the slough has formed an attempt should be made to remove it through a similar incision, scraping out with a spoon and swabbing with pure carbolic acid. Bier's cup or a ring of collodion painted round the margins of the lesion produces congestion, which often leads to a speedy cure. Yeast, levurine, carbon bisulphide, dilute sulphuric acid, stannoxyl, collosal manganese, and arsenic are each of them regarded by various authorities as being specific for the condition. The general health of the patient should be attended to.

*Vaccine therapy.*—Vaccines are valuable adjuncts to treatment in this condition. They can be used (1) to abort a boil, (2) to cure it when it has made its appearance, (3) to cause it to break down more speedily. (4) but especially when there are many boils all over the body occurring in crops which cannot be dealt with satisfactorily individually, or showing a tendency to recur from time to time. Variations in the dosage occur in each individual case. The use of a stock vaccine is usually quite efficient, but if this does not bring about a cure the use of an autogenous agent is indicated.

**Carbuncle.**—A carbuncle differs from a boil in that it is larger in size, has a tendency to spread marginally, and, instead of becoming conical, flattens out. The tissues around are brawny, and characteristically the skin gives way at several points instead of at the apex. There is gangrenous tissue in the centre, which forms large sloughs and involves the tissues deeper than in the case of furunculosis. The lesion is much more severe and liable to give rise to marked constitutional disturbances.

Diabetes, albuminuria, or acute septic infections are predisposing causes; the exciting causes are the same as for furunculosis.

Carbuncles are more commonly seen in men than in women; they are generally found on the back, on the nape of the neck, the sacrum, the face or scalp.

Owing to the depth to which they extend they are prone to involve important structures—*e.g.*, blood-vessels, nerves, or meninges; if they occur on the face, especially in the region of the upper lip, the liability to infection of the cavernous or lateral sinus by extension along the veins which drain into them makes the condition a serious one.

Death as the result of carbunculosis is not uncommon, a staphylococcal bacteriæmia usually supervening.

A carbuncle starts as a hard, painful swelling, with accompanying fever and occasionally a rigor. The patient looks very ill and is often markedly depressed. The swelling is an inflammatory process of low type which produces a

centrifugally spreading induration flattened on the surface, generally more or less circular, elevating the skin, and purple or dusky red in colour. Vesicles form on the surface at various points, and subsequently exude pus, exposing a similar greyish slough to that seen in a furuncle. The skin over this area eventually becomes gangrenous, and an ulcer is formed having undermined edges, indurated surrounding tissues, and a sloughy base. As the condition advances the patient acquires a sallow appearance, the temperature rises, and a delirious or low typhoid condition ensues, the patient dying from exhaustion, bacteriæmia, or pyæmia.

On the other hand the slough may be discharged, especially under suitable treatment, and recovery take place, the ulcer healing and leaving behind a scar which may be so considerable as to produce deformity. The condition is most serious when it occurs in people who are suffering from diabetes or albuminuria.

Sometimes the streptococcus is responsible for the condition, under which circumstance, whatever the age or general health of the patient, a grave prognosis should be given.

*Treatment.*—In the treatment of carbuncles the general health demands urgent attention. The patient should be in bed, lying in the position of greatest ease and avoiding pressure on the affected part. The food should be fluid and nourishing, and stimulants should be judiciously used as indicated by the pulse. He should be kept in the fresh air, and if there is much pain opium should be administered.

Locally the treatment consists in the first instance in the application of hot fomentations or hot baths, in order to aid the removal of sloughs.

Of the operative measures which are in use Bier's treatment by means of a cup sometimes has excellent results. Surrounding the lesion with a ring of collodion or injections of pure carbolic acid into its depths have also been advised.

Excision of the whole lesion if not too large, crucial incision with scraping and the application of pure carbolic acid and subsequent dressing of the wound with sterile gauze soaked in normal horse serum or hypertonic saline solution, meet with excellent results. The salt pack treatment gives good results. Ung. sorbefaciens has proved to be useful. As soon as the granulation tissue has become healthy, any of the methods which are used in ulcerative conditions already mentioned may be applied.

## Streptococcal Infections.

The *streptococcus* is a micro-organism which exists normally in many parts of the human body. Most varieties are saprophytic, and, even when they take on the characters of virulent micro-organisms, are little liable to produce serious lesions. The more virulent forms of streptococcal infection are produced by a particular member of the group, known as the *streptococcus pyogenes*.

The characteristic lesions for which they are responsible may be divided into two groups :—

1. A small primary lesion which has a tendency to diffuse rapidly through the neighbouring tissues, to involve a considerable area, the lymphatic vessels and lymphatic glands, and to disseminate *viâ* the blood-stream, producing bacteriæmia and often death.

2. The group in which the micro-organism shows a marked tendency to

remain localised to the primary focus of injury, producing a chronic lesion liable to be the origin of a long-standing bacteriæmic condition.

The first group may be exemplified by the conditions which result from the introduction of the *streptococcus pyogenes* into the finger while performing a post-mortem examination on a case killed by the same parasite.

Chronic joint lesions occurring coincidently with pyorrhœa alveolaris serve as an illustration of the second group. As a rule it is impossible to identify a streptococcus as the cause of a particular disease without a bacteriological investigation, but it is well known that the streptococcus is responsible for certain lesions, and this knowledge should lead to a suspicion of its presence.

*Bacteriology.*—The streptococcus was originally spoken of as consisting of two groups—the *streptococcus erysipelatosus* and all the other streptococci. Subsequently it was recognised that streptococci occurred in different lengths of chains; some of these were long and were known as *streptococcus longus*, others were short and therefore termed *brevis*.

Yet again, by certain biological phenomena and the knowledge that certain of them exist normally in the human tissues they have been named *streptococcus pyogenes* (which is now known to be the same as the *streptococcus erysipelatosus*), *streptococcus fæcalis* (owing to its normal existence in the intestines), *streptococcus salivarius* (owing to its normal existence in the mouth), and *streptococcus pneumoniæ* (or the *pneumococcus*). All these members have similar characteristics with the exception of the biological differences mentioned above. They stain quite readily with the ordinary dyes, give a positive staining reaction to Gram's method, and grow readily on ordinary media. In the case of pneumococci, however, blood has to be added in order to obtain a growth; moreover, they are relatively short-lived in artificial media. The *streptococcus pyogenes* and the pneumococcus are pathogenic to mice; the other members are less virulent, and will only slay animals when introduced in large doses.

**Streptococcus pyogenes.**—This micro-organism is the most virulent of the group, and is probably responsible for more deaths than any other. The initial lesion is commonly quite a small one; lymphatic and blood infection occur, associated with the acute onset of symptoms, rigors, high temperatures, delirium and even death, which may follow within a few hours. Amongst the fatal diseases due to this micro-organism may be mentioned lateral sinus thrombosis following otitis media, bacteriæmia following puerperal uterine infections, post-mortem bacteriæmias, etc. On the other hand, the lesions produced are not always quite so acute and are not necessarily fatal, as, for example, in cases of diffuse cellulitis following injury, erysipelas, etc.

**Streptococcus fæcalis.**—This micro-organism normally exists in the alimentary tract, especially in the large intestine. It is frequently found in peritoneal suppurations following a rupture or perforation of the bowel—*e.g.*, appendicitis, perforated typhoid or tuberculous ulcers—and occasionally it is found in the urinary tract associated with the *bacillus coli*. It is not regarded as an extremely dangerous infective agent, and is seldom found in the blood-stream after death.

**Streptococcus salivarius.**—This streptococcus normally exists in the mouth, and is most commonly associated with cases of Rigg's disease (pyorrhœa alveolaris), tonsillitis, infections of the antrum and the nasal sinuses, etc. It is also commonly isolated in lesions connected with the alimentary tract. Chronic endocarditis associated with lesions in these regions is also due to this coccus.

**Pneumococcus.**—Although this is regarded as a special micro-organism apart from this group, it is more strictly classified amongst the *streptococci*. The lesions which it produces are most commonly found in connexion with the lungs and the pleura. It is also found in suppurative processes of the pericardium, the peritoneum, the joints, meninges, and endocardium. The sinuses of the nose and antrum are commonly infected by it. It is responsible for a certain number of cases of acute otitis media and mastoiditis, the infection probably having arisen from the mouth and nasopharynx, in which situations the pneumococcus often lives as a harmless saprophyte.

In differentiating this micro-organism from the other members of the streptococcus group it should be remembered that it occurs in pairs, is lanceolate in shape, and each pair has a capsule surrounding it.

Whichever member of the streptococcus group is responsible for a particular lesion, it will be found that the characteristic feature is the production of an œdematous or phlegmonous inflammation commonly going on to suppuration, which spreads diffusely in the tissues. At the primary focus it is extremely liable to remain localised to the superficial tissues, although this is not always the case. The pus produced as the result of streptococcal infection is usually rather thin, watery and without odour. In the case of the pneumococcus, however, the exudation is of a fibrinous or sero-fibrinous type, the fibrin being recognised as flakes floating in the serum.

*Treatment.*—Before dealing with the treatment of streptococcal infections it should be recognised that in the majority of cases the prognosis is grave. The ordinary routine methods indicated in dealing with infections must be adopted and rigidly followed. Incision of the primary focus and isolation of the causal agent, the incision of infected lymphatic channels, the early recognition and opening of metastatic deposits, the introduction of serum and vaccine therapy in the earlier stages, are all called for. The two latter require special mention.

*Serum therapy.*—Many forms of serum have been recommended for use in dealing with these conditions; that most commonly in vogue is known as the *polyvalent antistreptococcal serum*, which is prepared by immunising animals with a mixture of a number of types of this group.

More recently, however, sera have been prepared which are antagonistic to indvidual members of the group, and these whenever obtainable are preferable to the polyvalent form, especially in cases of *streptococcus pyogenes* infection.

The serum should be introduced at the very earliest moment after a diagnosis has been arrived at, as it is of little value whenever there is evidence of general dissemination of the bacteria in the blood-stream. It should be given either subcutaneously or intravenously, in the latter case combined with large quantities of normal saline solution. Doses varying from 50 to 100 c.c. *per diem* should be used. In some cases the most remarkable results follow the use of these agents.

*Vaccine therapy.*—There is as yet no settled status as to the value of vaccine therapy in streptococcal infections. In conditions which are liable to recurrence, *e.g.*, cases of chronic erysipelas, there is no doubt that it is extremely useful. It should be utilised with care early in the treatment of acute infections. In many cases the improvement in the local signs and the general condition of the patient coincident with the introduction of vaccines, either sensitised or otherwise, in either acute or chronic conditions is so remarkable as to lead to the suggestion that they are of some value.

It is obvious that autogenous agents are a necessity. In the cases of chronic streptococcal infection associated with generalised dissemination very good results frequently occur, *e.g.*, in the case of joint affections secondary to some other primary infection.

In pneumococcal infections the prognosis is always, so far as surgical lesions are concerned, extremely grave. The opening of abscesses and the draining of serous cavities are the most that can be done; so far there is no evidence that either vaccines or sera are of any value.

**Erysipelas.**—Erysipelas is a particular form of streptococcal infection due to the *streptococcus pyogenes*. As a rule there is a primary site of inoculation, either a small local wound following the introduction of a foreign body, or else an infection of the skin set up by discharge from a sinus. Frequently, however, when the patient comes under observation there is either no wound to be seen or it has completely healed. The commonest lesion is associated with infection of the skin and subcutaneous tissues of the face, known as facial erysipelas.

A characteristic appearance is presented. The infection is said to arise from a small abrasion inside the nasal cavity Locally there appears a faint red blush of the skin, which rapidly spreads at its edges involving the nose and the cheeks on each side. As it spreads the edge becomes more and more definitely marked and raised; the colour of the skin also deepens; in the very acute forms the cuticle is raised into blebs, and occasionally sloughing may occur. The surrounding tissues, especially the eyelids, become markedly œdematous, often causing closure of the palpebral fissure. The inflammatory process lasts for varying lengths of time, and eventually gradually fades away. The disease is frequently ushered in with a rigor before the appearance of the local lesion, followed by a raised temperature, severe malaise, headache and sickness, which persist throughout the course of the disease, and ends with a crisis, the temperature falling to normal and remaining in that position.

Erysipelas is prone to recur, and may terminate as a chronic inflammation of the skin. It is also liable to spread from one part of the body to another; as one patch fades another makes its appearance—this is known as "wandering or transient erysipelas," a type frequently seen in children. It is difficult to differentiate between erysipelas and cellulitis of the subcutaneous tissues, the two conditions frequently coexisting.

When erysipelas spreads to or commences in the scalp, instead of remaining the intense red colour described above, the skin becomes quite white and œdematous. It is particularly dangerous when occurring in this situation, owing to the liability to infection of the meninges through some of the emissary veins.

Such a condition as above described may occur around any local primary focus in any part of the body.

*Treatment.*—A careful search should be made for the primary focus of infection if such is not obvious. If a primary focus is discovered the exudate should be bacteriologically examined. An open wound should be dealt with by the ordinary surgical methods. It is very seldom that the bullæ contain living *streptococci*, and unless there is primary focus it is extremely difficult to isolate the micro-organism.

In the majority of cases it is unnecessary to apply any local remedies. The affected part, however, should be protected by a pad of lint or sterile gauze to avoid the possibility of contact with the patient's hands, whereby the disease may be spread to other parts of the body. Cooling lotions or the use of starch powder and zinc oxide mixture often give relief, especially the former, as the moistening tends to keep the skin less tightly stretched.

The application of saline solutions by producing osmosis, *e.g.*, magnesium sulphate, has been found useful. A carbolised vaseline, ichthyol ointment, and iodine painted over the affected part may all be tried.

Antistreptococcal or normal horse serum applied locally is sometimes efficacious. In the more severe forms, and especially in parts where disfigurement does not require consideration, scarification or incision is useful. Attempts are occasionally made to limit the spread of the lesion by injection of solutions of (1 in 20) carbolic acid or horse serum around the margin. The painting of the spreading edge with iodine tincture acts in a similar manner. Fomentations are as a rule to be avoided.

The patient should be in bed; the bowels should be vigorously purged; the diet should be light. In the milder forms of the disease the condition will subside in twenty-four to forty-eight hours, and as soon as the attack has passed over a generous diet should be given. In elderly people especially stimulants are indicated; champagne, brandy, strychnine and phosphoric acid are all useful. Certain drugs are said to be specific for the condition—perchloride of iron, quinine and sodium salicylate; the two latter probably act merely as antipyretics.

*Serum therapy.*—The antipyogenes serum is the type advised, although if this cannot be obtained the polyvalent variety seems to be almost equally efficacious. Initial doses of 50 c.c. into the subcutaneous tissues and subsequent daily inoculations of 25 c.c. at least should be given. If a speedy result is desirable intravenous injections may be substituted; the effect is sometimes instantaneous, the temperature falling to normal within a very few hours.

*Vaccine therapy.*—If an autogenous agent cannot be prepared owing to failure in isolating the particular infecting agent, a mixture of stock virulent pyogenes vaccine should be utilised. Sensitised vaccines are said to be more useful; the dosage depends upon the severity of the infection.

As a rule 25 to 50 million will cause little harm, but it is quite impossible to lay down definite rules, each individual case requiring judgment on its merits. Here again immediate resolution may occur, and yet in other cases no obvious benefit is obtained.

In recurrent conditions prophylactic measures are of first importance. The clothing should be thoroughly disinfected, carbolic baths given, and any primary focus which can be found should be vigorously dealt with. Vaccine therapy is extremely successful in this condition.

Pain is a symptom which often calls for treatment, morphia being required. Delirium combined with high fever will usually disappear as soon as antipyretic measures are adopted.

**Cellulitis** differs from erysipelas in that it not only involves the cutaneous tissues but also the subcutaneous and intermuscular layers. It is usually associated with a punctured wound of the skin and spreads *viâ* the lymphatics. The skin is less markedly red; œdema is diffuse. The swelling rapidly becomes soft and boggy, and sloughing of the skin over these areas follows. The pus formation does not tend to come to the surface, but to spread underneath the skin until a very considerable area has become involved. The symptoms are those of pain and swelling, high fever and general illness; bacteriæmia and pyæmia are extremely prone to be associated with this condition.

*Treatment.*—The condition should be dealt with exactly as in the case of erysipelas, except that a more careful look-out for the spread of the condition should be kept, and early incision of the tissues vigorously adopted.

**Ludwig's angina.**—The cervical and submaxillary lymphatic nodes become acutely inflamed, secondary to inflammatory conditions of the teeth, tonsils, mouth, and pharynx, and this, associated with infection and œdema of the cellular tissues of the neck, is called Ludwig's angina. Suppuration supervenes. A *streptococcus* is the commonest cause of the infection.

*Symptoms.*—Accompanied by fever, often an initial rigor, a deep-seated swelling, ill defined in outline, is found in the submaxillary region. The floor of the mouth becomes œdematous, the tongue being lifted towards the roof of the mouth ; the pharynx and larynx are also involved, resulting in dysphagia and dyspnœa.

Later the cellular tissues of the neck become affected, the whole area being hard and brawny, causing stiffness, and, if suppuration tracks down to the mediastinum, pericarditis, broncho-pneumonia, and empyema may follow. Profound toxæmia is a prominent symptom.

The condition is an extremely grave one, and unless surgical measures are speedily resorted to death from sepsis or suffocation will result.

*Treatment.*—As soon as the condition is recognised, multiple deep incisions must be made into the œdematous tissues, and any small collections of pus must be drained. Superficial incisions are of little use. Owing to the proximity of important vessels and nerves, the deeper dissection should be made with blunt-pointed forceps.

Temporary tracheotomy may be required if dyspnœa becomes urgent. The use of antistreptococcal serum is sometimes efficacious in this condition.

## Diphtheritic Infections.

The diphtheria bacillus is a micro-organism which is responsible for localised lesions from which it sets free its toxins into the general circulation, producing a toxæmia. The bacillus is not found in other tissues apart from the primary focus of infection ; it is in this characteristic allied to the tetanus bacillus, which acts in a similar manner. The bacillus attacks man, animals, and birds. It is usually conveyed from person to person through the breath or sputum, but may be transferred by the milk or water supply.

People of all ages are liable to infection, but especially children.

The primary foci of infection are the tonsil, the fauces, the larynx and trachea, the nasal mucosa, the conjunctiva, the vagina, and wounds. The condition is recognised by the appearance of a false membrane of fibrin entangling cells and bacilli attached to one of these sites, associated with the presence of the diphtheria bacillus.

*Bacteriology.*—Film preparations stain easily by methylene blue and by Gram's method; special staining by Niesser's method demonstrates the presence of polar bodies at each end of the bacillus. It is a short, rod-shaped bacillus with rounded ends, non-flagellate, non-motile, and does not bear spores ; it is usually arranged in characteristic Chinese-pattern figures or in pairs. It grows most readily in inspissated blood serum, and it is in a film preparation of a twelve-hours culture on this medium that polar bodies are best demonstrated. The presence of a polar-staining, Gram-positive bacillus in a lesion covered by a false membrane is strongly suggestive of diphtheritic infection. Confirmation by certain bio-chemical tests, and inoculation into a guinea-pig producing death within thirty-six hours, is requisite for a certain diagnosis.

The micro-organism has to be distinguished from certain other diphtheroid bacilli which frequently contaminate wounds and are quite harmless.

Certain other clinical phenomena are associated with the local lesion; especially albuminuria, muscular weakness, and attacks of syncope; later, paralyses of muscles in pharynx and limbs may ensue. In the air-passages mechanical obstruction may occur. Bacilli may remain in the lesion for a considerable period of time, the patient becoming a "carrier."

*Treatment.*—Surgical treatment may be called for in dealing with difficulties of breathing—*e.g.*, tracheotomy or intubation may be required. Local wounds should be treated as other wounds. Isolation of the patient is requisite in all cases.

*Serum therapy.*—Inoculations of serum are most efficacious: 2,000 to 8,000 units should be given as an initial dose into the subcutaneous tissues and repeated if necessary.

## Anthrax.

The anthrax bacillus most commonly produces its lesions in cattle, horses, sheep and goats, etc.; it causes an epidemic disease; it only rarely attacks man. It is responsible for disease among workers in certain trades, namely, those dealing with hides or skins, either in the natural or prepared state.

Hide-porters, wool-sorters, waterside labourers, horsehair workers, and the like are most liable to infection, and thus the disease is prone only to occur in those districts which house them. The disease is known to exist amongst these people, and special precautions are taken both by them and the Ministry of Health to prevent infection.

In man anthrax occurs in three forms—as a lesion (1) of the skin, (2) of the pulmonary tract, and (3) of the alimentary tract. Yet a further form, occurring as a bacteriæmia without an obvious primary focus of infection, is known, and goes by the name of anthracæmia.

Cutaneous anthrax is the form most commonly met with in surgical practice; pulmonary and intestinal anthrax are seldom diagnosed during life, only being recognised in the post-mortem room after bacteriological investigation. The lesions have a characteristic feature, namely a small localised area of inflammation, which speedily becomes surrounded by a dense area of œdema and lymphangitis, often so severe as to be accompanied by blood extravasation in the tissues.

*Pulmonary anthrax* is commonly known as "wool-sorters' disease," from the fact that infection takes place by the inhalation of small particles of infected wool. The original lesion is in the bronchi, and is associated with the characteristic œdema with a subsequent onset of acute pneumonia and rapid death. The cases are rarely recognised unless such a condition is found among persons living in likely districts of infection, *e.g.*, Bradford, when systematic bacteriological investigations render diagnosis possible. The result is always fatal.

*Intestinal anthrax* affects any part of the alimentary tract from the mouth to the anus. Most commonly the lesion is found in the small intestine, giving rise to an acute attack of enteritis and collapse. The patient dies within a few days in a condition of anthracæmia.

*Cutaneous anthrax.*—This condition is more commonly known as "malignant pustule" or "charbon," the former term improperly suggesting the character of the lesion, for at no time does it show a tendency to suppurate unless secondary infection supervenes. The lesion, which appears as a rule from one to three days after the introduction of the micro-organism through a wound in the skin, is mostly seen on the exposed surfaces of the body.

The sites most frequently affected are the skin of the face just below the orbit, of the chin, of the back of the neck, and the forearm.

The lesion exhibits variable characters. Most typically it appears as small painful pimple surrounded by a considerable area of redness and œdema. The papule quickly becomes purple in colour and vesicular. Later a scab forms, which is composed of necrotic tissue and blood, known as an "eschar." Around this are collected in a ring a number of vesicles containing clear or faintly turbid fluid, the skin around becoming intensely red, œdematous and brawny. Painful enlargement of the lymphatic nodes also takes place; they rarely suppurate. Occasionally the œdema is present without an obvious local focus, a condition termed "anthrax œdema." The cutaneous lesion shows some tendency to resolve spontaneously.

The œdema may become so severe as to involve important structures in the neck, the vessels, trachea, larynx, etc.

Blood infections may occur either by a spread of the anthrax bacillus into the blood or of some of the other micro-organisms which frequently infect the lesions in the advanced stages; this usually takes place within a week to ten days.

Constitutionally the patient exhibits general malaise, great in proportion to the extent of the lesion; a raised temperature and even rigors may be present.

FIG. 3.—Malignant pustule. From a case under the care of the late Morrant Baker.

Anthracæmia is a condition in which the bacilli are circulating in the blood-stream. It is not often met with, except in those cases which have been untreated, or in the pulmonary and intestinal forms of the disease. Clinically, the temperature is considerably raised, the pulse is fluttering, and the symptoms of collapse are markedly evident; vomiting and diarrhœa are prominent symptoms; the patient dies in a condition of delirium or coma. In the post-mortem room there is little evidence of disease beyond the demonstration of the bacillus in the blood-stream. Meningitis, subarachnoid and subpial hæmorrhages, both in connection with the brain and the cord, are usually present; subserous hæmorrhages and enlargement of the spleen are also found.

Cutaneous anthrax has sometimes to be distinguished from an ordinary furuncle. The occupation of the patient, the somewhat unusual site of the lesion, and the appearance of the vesicles are all suggestive, but the demonstration of the bacillus is essential for diagnosis; the latter should be isolated from the fluid in one of the vesicles.

The other lesions are rarely diagnosed unless the excreta of the alimentary and pulmonary tracts have been examined as a routine method of investigation. A cultivation of the blood may be helpful.

*Bacteriology*.—The anthrax bacillus is a very large micro-organism, being

5—10 $\mu$ long and 1—1·5 $\mu$ broad: it is rod-shaped with square ends: it stains with all the ordinary dyes and by Gram's method: it is non-motile, having no flagella: it possesses a centrally-placed spore, which, however, is never found in the living tissues, but only in the dead body; this spore is extremely resistant to all external destructive agents, and for this reason special precautions have to be taken in dealing with the clothing and utensils used by an infected person. It is by means of the spore, as a rule, that infection takes place.

The bacillus grows quite easily on all ordinary media within twelve to eighteen hours, with characteristic appearances.

A mouse dies within twenty-four hours of inoculation, and the micro-organism can be isolated from its spleen.

*Treatment.*—Cutaneous anthrax is the only form of infection by this bacillus which as a rule calls for treatment. Pulmonary and intestinal anthrax need not be considered here.

1. *Prophylaxis.*—The bedding, the bedclothes, the towels, handkerchiefs, etc., and all other destructible articles should be burnt; feeding utensils, bowls, etc., require to be sterilised at a very high temperature. The necessity for this procedure is due to the fact that the spores of the bacillus are extremely resistant to all external agencies. The lesion should never be touched with the fingers unless the latter are covered with rubber gloves. The nurses should be dressed in overalls.

Should the patient die, an autopsy is forbidden, owing to the formation of spores in the human tissues after death. Special methods of burial are advised, the body being placed in a bed of lime.

2. *Expectant treatment.*—This depends on the natural immunity, or the power of acquiring such, which the body possesses; it is not a method which should be advocated, for although resolution is known to occur without any form of treatment being adopted, it is by no means always a successful process.

3. *Methods depending on the destruction of the lesion.*—Various methods can be used—*e.g.*, cauterisation with nitric acid, carbolic acid, the actual cautery, or other forms of caustic; incision, combined with the local application of antiseptics; and excision. Excision is that most commonly favoured, and more often averts a fatal issue.

In carrying out excision the whole of the lesion, together with a good surrounding margin, should be extirpated and the wound allowed to granulate up, with or without the previous application of some form of caustic. This method is, in many situations where cutaneous anthrax lesions occur, to be strongly advocated, but in certain positions—*e.g.*, the commonest, just below the orbital margin—such a severe operation is liable to result in contractions of the tissues and lead to secondary lesions which cause considerable disfigurement, *e.g.*, ectropion; moreover, the healing of the wound often extends over a considerable period of time, a point to be considered in dealing with the working classes.

4. *Serum therapy.*—This was first instituted by an Italian named Sclavo and introduced into this country by Legge. The serum is prepared from the blood of the white ass of Piedmont, an animal which is particularly susceptible to infection. The treatment consists in the introduction of large doses of the serum into the subcutaneous tissues; the initial dose should not be less than 40 c.c., a similar dose being repeated if necessary. Results of the inoculations vary. In the majority of cases there is no marked local or general reaction but sometimes there is considerable rise of temperature and increase in the

general malaise; the lesion may appear to progress in severity and may cause some anxiety. Within eighteen to twenty-four hours, however, these symptoms and the lesion will subside. If cultivations are made at this period it will be found that the bacilli are no longer alive.

The advantages of this treatment are that it is almost invariably successful, the lesion leaves little or no scar, and the period required for isolation is diminished.

In advanced cases a combination of incision and serum therapy is advised, and even in those cases where excision is considered to be the correct method of treatment it is desirable at the same time to introduce the serum.

If the diagnosis of internal anthrax is made, serum therapy is the only method of dealing with the condition. As a rule no harm results from the injections beyond the liability to serum disease.

## B. Coli and Typhoid Infections.

This group of bacteria includes a large number of micro-organisms resembling each other very largely in morphological characters, but differing in certain bio-chemical properties. It includes *B. coli communis*, *B. typhosus*, *B. paratyphosus*, *B. pyocyaneus*, and *B. proteus* as the more important members.

**B. coli communis.**—This is the chief member of the group, and is responsible for more pathological conditions than the others. It normally exists as a saprophyte in the alimentary tract, being found especially in the lower part of the small intestine and the colon. It is also found in the skin around the anus and in the vagina.

*Bacteriology.*—It is recognised by the following characteristics:—A bacillus, 1 $\mu$—5 $\mu$ long, rod-shaped, with rounded ends; exhibits active motility, due to the possession of numerous lateral flagella; does not produce spores; grows quite readily on ordinary media within a few hours; also possesses the property of gas formation and lactose fermentation; does not liquefy gelatin: when inoculated into animals, as a rule, it only forms a local abscess. In film preparations it stains easily with the ordinary dyes and is Gram-negative.

Its pathogenic effects in man are most often exhibited in connexion with the region of its natural habitation, namely, the alimentary tract, but there is no part of the body immune from infection.

*Infections of the alimentary tract.*—It is seldom the cause of lesions within the tract itself. When, however, any form of obstruction to the bowel occurs —*e.g.*, strangulation by bands, herniæ, tumours, etc.—the bowel becomes paralysed and dilated. The colon bacillus under these circumstances passes through the wall of the distended bowel and, together with the other intestinal flora, sets up peritonitis. There is some doubt as to the actual part played by the bacillus.

It is the commonest micro-organism found in an appendix abscess, subphrenic abscess, or liver abscess associated with alimentary canal suppuration.

The presence of the micro-organism is usually recognised by the foul odour of the pus, and occasionally by small quantities of gas which it produces. The pus is usually thick and slimy.

It is also a cause of gall-bladder and pancreatic infections of a chronic type, and has frequently been demonstrated in the centre of gall-stones.

*Infections of the urinary tract.*—In the female the bacillus is frequently found in this tract apart from the presence of symptoms, a condition spoken of as

*bacilluria*. There may be no lesion present; but if for some reason an injury to the tract occurs—*e.g.*, obstruction to the ureters in pregnancy—acute symptoms are liable to occur, often leading to disastrous results.

There are two types of infection of the urinary tract by this micro-organism—the acute and the chronic.

In the first, infection probably takes place through the blood-stream, and is usually shown by the onset of symptoms of acute cystitis, with or without symptoms of pyelitis and nephritis. The condition lasts about three weeks and then subsides, all the bacilli disappearing from the tract; if unsuitably treated a chronic bacilluria is prone to occur.

The other type is a chronic infection usually, though not necessarily, dependent on and associated with some injury or obstruction to the urinary tract—*e.g.*, calculi, enlargement of the prostate, stricture of urethra, etc.

This form of infection must be distinguished from that due to another member of the group, namely, the *B. proteus*, which is usually a more virulent micro-organism and more difficult to deal with. It is distinguished from *B. coli communis* in certain cultural properties.

*Other parts of the body affected.*—It is occasionally found in empyemata of the thorax and antra, otitis media, bronchiectasis, and very rarely in joint lesions of a chronic type. It frequently causes secondary infection in wounds primarily due to some other micro-organism.

*Treatment.*—The infections due to *B. coli communis* do not call for any special line of treatment beyond measures applied to the alimentary tract—*e.g.*, purging, the use of antiseptic drugs, and irrigations.

A serum has been used, but there is little evidence of its value. Vaccine therapy has been largely advocated in dealing with these bacillary infections. There is a natural tendency for the acute conditions to subside as soon as antiseptic measures have been applied to the alimentary tract, no matter in what part of the body the lesion is situated. Under these circumstances the use of vaccines is seldom called for; in the more severe lesions, however, they do occasionally appear to act in a miraculous manner when given in suitable doses.

In chronic lesions there is a general tendency towards persistence, especially in the urinary and biliary tracts. If symptoms are present they may be relieved by the use of vaccines, and to a considerable extent the conditions will improve, but seldom completely clear up, even if the primary cause of the condition—*e.g.*, enlarged prostate—is removed.

**B. pyocyaneus.**—A bacillus closely resembling the colon bacillus, but differing from it in that it is more actively motile, liquefies gelatin, and produces a bluish-green pigment.

It normally exists in the alimentary tract and is but seldom responsible for pyogenic lesions in the human body. It is most often found in wounds of a chronic character, especially sinuses associated with other bacteria, and is the cause of a bluish-green colouration of the pus. Unless precautions are strictly observed, it is very prone to be carried from patient to patient in a hospital ward. As a rule it is difficult to get rid of the bacillus from such a wound by the ordinary antiseptic methods, but it will sometimes speedily disappear after a single inoculation of a vaccine prepared from it.

**B. typhosus.**—The bacillus responsible for typhoid fever. It concerns surgeons both during the disease and also in connection with lesions occurring many years after the initial infection.

*Recognition of the bacillus.*—Morphologically it exactly resembles the *B. coli communis*, with the exception that it is possessed of more flagella It differs,

however, in certain cultural properties; although it grows quite readily, it does not ferment lactose, clot milk, or produce gas. Moreover, the bacilli are distinguished by the fact that when brought into contact with the serum of a person known to have or have had typhoid fever, they are agglutinated (Widal's reaction).

It can be isolated from the blood of a patient suffering from typhoid fever during the first week of the disease, and from the stools during the whole course of infection. It is also present in the urine. Infection takes place, as a rule, by contamination of the water of an infected district through the fæces or urine. It may also be transmitted by the hands of the doctor or nurse.

Although the bacillus apparently dies out after the disease has come to an end, in a certain number of cases it persists either in the alimentary tract or one of its diverticula (usually the gall-bladder), in the urinary tract (usually the kidney), or the bone marrow. Possibly this event occurs more commonly than is supposed, thus accounting for the appearance of lesions many years after the fever has subsided. Such a person is said to be a "typhoid carrier."

The surgical lesions occurring during typhoid fever appear at different stages of the disease. It is probable that the majority are due to other forms of bacteria, rendered active by the lessened resistance of the tissues, but occasionally the typhoid bacillus is isolated. The more common lesions are phlebitis, mostly seen in the vessels of the leg and usually appearing within the first fortnight of the disease; arterial thrombosis; and the resultant of these two conditions, a moist or dry gangrene, which may require surgical measures. Synovitis with effusion into joints is sometimes seen during the course of the infection and occasionally during the convalescent stage. Orchitis, epididymitis, perichondritis, etc., are other complications.

The ulceration of the intestine (lower part of ileum, cæcum or appendix) may pass on to acute perforation during the third week of the disease, giving rise to a local or general peritonitis, usually the latter, but dependent on previous chronic peritonitis around the base of the ulcer. The peritonitis so set up is probably not so much due to the *B. typhosus* as to the other bacteria present in the bowel. This view is supported by the fact that, if localised abscesses form in the peritoneal cavity subsequently, the bacillus can seldom be recovered unless a fæcal fistula also persists. During the acute stages of the disease the other serous cavities and tissues of the body may become involved owing to the supervention of bacteriæmia or pyæmia, meningitis, empyema, or broncho-pneumonia.

Of the chronic lesions those occurring in the gall-bladder, kidneys, and bones are the more common. The former is most frequently seen in the form of chronic cholecystitis, with or without an acute exacerbation, and usually associated with gall-stone formation. As a rule the condition is not suspected as being due to this bacillus unless a routine bacteriological investigation is made of the gall-bladder contents. It is extremely important that this should be done in all cases of this type, as a person so infected is a danger to the community, being able to infect others through the fæces.

Bone lesions occur most frequently in the form of suppurative periostitis; the tibia and the ribs are the more common sites. Probably this starts as an osteomyelitis, the bacillus being located in the bone marrow.

The recognition of these various conditions depends on the isolation of the bacillus either from the blood or the bowel; if this fails Widal's reaction should be resorted to. This test is considered to be so reliable that a positive reaction is diagnostic of the condition.

*Treatment.*—The treatment of isolated lesions will be dealt with elsewhere. Specific methods of treatment depend on isolation of all patients infected with the bacillus. Urotropin or borovertin are useful drugs in conditions associated with the biliary and urinary tracts. Alimentary antiseptics are strongly indicated. Surgical interference in chronic gall-bladder and urinary lesions is advocated.

Vaccine therapy has been largely used in dealing with enteric fever, but more especially as a prophylactic agent for persons who are going to live in "typhoid" districts; its value in this direction was greatly emphasised during the war. Typhoid vaccines have not so far met with success in the treatment of chronic lesions.

## Tuberculous Infection.

The bacillus of tuberculosis is a micro-organism responsible for a specific type of chronic inflammation of common occurrence. The frequency of infection by this bacillus is illustrated by the following figures: in the year 1917 there were 55,934 deaths from tuberculosis of all forms in England; infections due to the bacillus are notifiable; in 1918, 92,000 fresh cases were notified. It infects both animals and human beings; the initial lesion which it produces is known as a *tubercle*. Persons most commonly liable to infection are those between the ages of five and fifteen, but no age is exempt.

*Mode of infection.*—The bacillus normally exists in excreta from persons or animals already affected with the disease—*e.g.*, it is found in the dust of the street (from dried sputa, etc.), in certain foods (milk, meat, etc.) and so forth, and it is by this means that it is conveyed to man. There is a greater liability to infection in certain people, probably due to the fact that the soil in some is more receptive for the micro-organism than it is in others, for all are exposed to infection. This liability may be acquired as the result of certain chronic diseases which so lower the resistance of the tissues as to make the soil suitable; this may be instanced in the case of those who have rickets, chronic lung affections, and chronic septic conditions, and those who live in bad surroundings and are improperly fed. In man the micro-organism would appear to have a special affinity for certain tissues, although any tissue may be attacked; take, for example, the serous membranes; the pleura, peritoneum, and the meninges commonly become involved, whereas the pericardium and the tunica vaginalis are seldom the seat of disease; again, of the solid organs, the kidney and testicle are commonly the foci of primary infection, whereas the liver and spleen are seldom involved in this way, although, in a disseminated tuberculosis, lesions are commonly seen in the latter. Joint disease in children is very often observed in connection with the knee and hip, whereas other joints are less frequently involved; yet again, in certain joints the synovial membranes appear to be particularly liable to infection, whereas in others it is the bones forming the articulation in which the primary focus arises.

Surgical tubercle is most commonly seen in children, less often in adults, and rarely in old people; in the latter, the disease known as senile tuberculosis must always be kept in mind, as cases from time to time occur in which an early recognition of the condition is exceedingly desirable.

The routes by which the bacillus gains admission to the tissues are three:—

1. *Inhalation.*—The respiratory tract is a favourite route by which infected dust may gain an entrance, the tonsil and bronchi being particularly vulnerable situations.

2. *Ingestion.*—The food may infect the tonsil or, lower down in the intestinal tract, the Peyer's patches.

3. *Inoculation.*—Occasionally lesions are found in the skin for which the tubercle bacillus is responsible, probably at the site of some small wound. Such conditions as butcher's or post-mortem wart occurring on the fingers are recognised as having their origin in this way. Certain forms of lupus are similarly classed.

A tuberculous lesion does not necessarily occur at these primary sites of entrance, which may simply serve as an area on which the bacillus rests, later to be absorbed into the lymphatic channels which drain these various regions, and it is here that the bacilli set up the inflammatory process. It is true that they may not become active, but may remain in a latent condition until such a time arrives as is suitable for the production of the lesion. On the other hand, a localised tuberculosis may occur, as is shown by the enlargement of the lymphatic glands involved.

Varying changes follow infection. Firstly, the lesion may remain localised; secondly, it may go through the process of resolution, the glands returning to a more or less normal condition under suitable circumstances; thirdly, the process of healing may be by fibrosis. On the other hand, degenerative changes may occur; caseation appears (which may still heal by fibrosis or calcification); or an abscess may form which is liable to become secondarily infected by pyogenic micro-organisms.

During any of these stages the infection may involve neighbouring structures—*e.g.*, the lungs in the case of the bronchial glands, or the peritoneum in the case of the mesenteric glands; or, what is more common, the micro-organism may be disseminated by the blood-stream to some other tissue which at the time is in a state of lowered vitality, as exemplified in infections of the genito-urinary tract or a joint. Here the process is repeated, passing through a stage of localised infection, involvement of neighbouring structures, and yet again a secondary blood infection which is usually of a much more severe character than that above instanced, for it leads to the condition which is known as *disseminated tuberculosis;* small tuberculous foci are found in all the tissues of the body, especially in the lungs, the spleen, the liver, and the meninges; the patient dies most commonly of broncho-pneumonia or meningitis.

Yet another complication is that one of the pyogenic micro-organisms infects such a lesion, and forms an abscess which either by treatment or spontaneously leaks on to the surface of the body, and in the course of time either a septicæmia or pyæmia is produced, or lardaceous disease supervenes. These are other conditions of which persons suffering with tuberculosis may die.

The commoner infections by the tubercle bacillus which come into the hands of the surgeon are those involving the lymphatic glands, especially the cervical and mesenteric, the bones and joints, the kidney and the epididymis in the urinary tract, the tongue and tonsil and larynx in the respiratory tract, the appendix and anus in the alimentary tract, and the peritoneum and pleura among the serous membranes; each of these will be discussed under the various headings.

*Recognition of the disease.*—Infection by the tubercle bacillus makes itself evident in two ways. There is, as a rule, evidence of constitutional disturbance; the temperature chart shows regular elevations, usually during the evening, at which period the patient will complain of sweating; the patient becomes anæmic and wastes, especially if residing in unsuitable surroundings.

Secondly, as a rule there is definite clinical evidence of a localised lesion: although one may suspect the tubercle bacillus as being responsible for such a condition, it is recognised that in order to make the evidence complete the aid of the bacteriologist and the histologist is usually necessary. Conditions previously considered to be tuberculous are now recognised by these means as being due to other agents of infection; therefore the demonstration of the tubercle bacillus should if possible always be carried out (*e.g.*, examination of the sputa, of the urine, of the fæces, of the fluid contained in joints, of the cerebro-spinal fluid, of the peritoneal exudate, and of the scrapings of ulcers can usually be carried out if suitable methods are adopted). Even if by these means it is not possible to find the micro-organism, removal of small pieces of the diseased tissue with subsequent histological investigation will often aid in the diagnosis; and yet again, if these fail, the introduction of the suspected material into a susceptible animal, *e.g.*, the guinea-pig, will often produce a lesion which is sufficient evidence to certify the infection.

Certain other methods are in use—*e.g.*, the estimation of the opsonic index and the use of certain serum reactions—but it must be remembered that none of them are of so much value as the demonstration of the bacillus.

Unlike most of the micro-organisms already mentioned, the tubercle bacillus is extremely difficult to stain. Film preparation of concentrated deposits stained by the Ziehl-Nielsen method is that most commonly used. It does not stain by the ordinary dyes except after a very prolonged period of time. The bacillus is 3 $\mu$ long and 0·3 $\mu$ wide, beaded in appearance, without flagella and without spores; it is exceedingly difficult to cultivate on artificial media; a growth can be obtained on egg media within a week and on inspissated serum within twelve days.

*Examination of tissues.*—The histology of the condition is of much practical importance.

Stage 1.—In the early stages a structure is found spoken of as a "*grey miliary tubercle*"; this consists of a conglomeration of a number of large cells, probably derived from the connective tissues, which are known as the endothelioid cells; in the centre is often found a cell of much larger size, probably derived from these and containing a large number of nuclei arranged round its periphery; outside is another circle of small round cells which are lymphocytes of the blood-stream. In favourable circumstances a ring of loose fibrous connective tissue will surround the whole. This structure therefore shows evidence of the reaction of both the connective tissue and the hæmic elements; of these the former is the more important. The structure is completely avascular. By the special staining method above mentioned the bacillus can sometimes be demonstrated in the tubercle, centrally placed either in or around the giant cell; it can be more often demonstrated in the acute than in the more advanced lesions.

Stage 2.—Dependent on the action of the toxins excreted by the bacillus and the cutting off of the blood supply, the central portion of this tubercle undergoes a curious type of necrosis spoken of as *caseation*, the lesion produced being recognised as the "*yellow tubercle.*" Microscopically the centre of the grey tubercle has undergone such a change that the majority of the endothelioid cells and the giant cells have become converted into a homogeneous mass, the bacilli, if still present, being found at the margin of this caseous tissue. Occasionally a fibrous ring completely surrounds the tubercle, resolution occurring; but what more commonly happens is that a number of these tubercles fuse together to form a larger caseous mass, which may

remain localised and latent for a period of time, and may subsequently calcify or else liquefy, producing an abscess clinically spoken of as a *cold* abscess.

This histological evidence is often sought for by the surgeon.

*Animal inoculation.*—Some of the tissue, either fluid or solid, is introduced into the subcutaneous tissues of the thigh of a guinea-pig. About the end of the third week a localised caseous or suppurative lesion appears, which, if investigated, will be found to contain the tubercle bacillus; at the same time the glands in the groin become enlarged. At the end of six weeks or two months the animal dies of generalised tuberculosis, lesions being found in the spleen, liver and lungs, and the bacillus demonstrated in such if examined. This method of investigation obviously is disadvantageous if the bacillus can be otherwise demonstrated owing to the length of time required for carrying it out, but it is of advantage in certain circumstances.

### *Other Methods of Diagnosis.*

*Opsonic index.*—In recent years an estimation of the opsonic index under varying conditions extending over a period of time, to eliminate changes due to exercise and massage, etc., has been in vogue, and variations in the curve charted are taken as evidence or not of tubercle.

*Use of serum reactions.*—Several of these have been put forward. The inoculations which give the most satisfactory results follow the subcutaneous injection of Koch's "old tuberculin." It is given in four doses—0·5, 1·0, 5·0, and 10 milligrammes—with intervals of three days between each. Observations are made on the course of the temperature chart and clinical changes observed in the local lesion suspected of being of a tuberculous nature. A rise of temperature of one degree and an increase in the local symptoms or signs suggest a positive result. This is known as the *subcutaneous test*, and is probably more reliable than all the others in use. Unfortunately it has the disadvantage that it cannot be utilised when pyrexia is present, thus limiting its application. In the case of children the doses above mentioned should be halved.

Another method of using tuberculin is that described by von Pirquet and known as the *cutaneous reaction*. As in Jennerian vaccination, the skin on the flexor aspect of the forearm is scratched in two places with the point of a knife just sufficiently to open up the apices of the papillæ, as far as possible avoiding bleeding. On to one of these patches a drop of the tuberculin is allowed to soak in, and on the other a drop of glycerin is placed as a control. Within twenty-four hours a localised inflammatory reaction appears in the form of a papule, surrounded by an area of inflammation; during the next three or four days this will subside; on the control patch nothing happens.

More recently, this method has been amplified by using graduated doses of tuberculin in a series along the arm, the smallest dose ($\frac{1}{64}$ milligramme) being placed at the lower end and the full strength at the upper end, and it is said that in this way the degree of infection by the tubercle bacillus can be gauged, and from time to time the progress of the disease can be estimated.

The value of this test is still doubtful, but it is true to say as a rule that in children a negative reaction means that the bacillus is not producing an active lesion.

*Calmette's ophthalmic reaction* has been given up as dangerous, even if the discomfort alone does not contra-indicate its use.

*Treatment.*—As a general principle it must be recognised that infection by the tubercle bacillus is one from which the patient will spontaneously recover

under suitable conditions. The object of treatment, therefore, should be to render the patient physically fit to resist infection, and if infection has already occurred, so to raise the resistance of the tissues that they will overcome the action of the toxins. Although the active symptoms may subside, the localised lesion may still persist in a latent condition, and therefore an effort should be made to maintain the resistance at a high standard. Secondly, attempts should be made to neutralise the effect of the bacillus by the use of specific methods of treatment. Thirdly, many surgical lesions can be dealt with either palliatively or by operations; and lastly, especially in joint lesions, the resultant deformities may require surgical interference.

With regard to building up the tissues the use of nourishing diet, especially one containing fat products in the shape of milk, cream and bacon fat, supplemented by cod liver oil and malt, is of first importance. The general hygiene should be improved as far as possible, using open air and sunlight such as can be obtained by residence at the seaside or in higher altitudes. Massage to the affected tissues, providing better circulation, is often of considerable use if carried out in suitable cases.

Of the drugs which are the more useful, tonics in the form of iron and phosphorus help to overcome the anæmia, and as a specific treatment the inoculation of various forms of *tuberculin* may be tried. Of the latter those most in favour are Koch's new tuberculin T.R. and the bacillary emulsion, the dosage varying from $\frac{1}{100.000}$ to $\frac{1}{500}$ milligramme. Some surgeons prefer to control the use of these agents by estimations of the opsonic index, but usually it is found that as good results can be obtained by observing the clinical course of the condition—*e.g.*, the use of the temperature charts, the increase or diminution in the local signs and symptoms of the disease, and the improvement in the general health of the patient. If tuberculin is to be of much use it must be given over an extended period of time. It is notoriously preferable for certain diseases, *e.g.*, adenitis and genito-urinary tuberculosis. There is little evidence, however, that it is of value in the treatment of joint diseases and those of the serous membranes.

Locally the treatment consists in putting the affected part to rest. This is especially important in the case of a tuberculous joint or bone infection. On the other hand, methods which will bring to the part increased vascularity—*e.g.*, Bier's treatment, the use of X-rays and Finsen light, and application of Scott's dressing—have their advantages. If these fail surgical interference will be called for. In certain conditions, it is often important that the primary focus of infection should be removed in the earlier stages, as it is known that if such is not carried out the disease will spread to the surrounding tissues, causing damage which may be irreparable. Such conditions may be exemplified by the tuberculous cystitis which often follows tuberculous disease of the kidney, and disease of a joint subsequent to infection from a primary abscess at the end of a long bone.

The treatment of abscesses has been dealt with under another heading (*Treatment of Chronic Abscess*). When generalised tuberculosis has set in nothing can be done for the patient except by palliative means and by treating the symptoms as they appear.

### Streptothrix Infections.

The commonest micro-organism of this group met with in this country is known as *actinomyces or the ray-fungus*. It is probable that this is not the only member of the group that causes infection.

A disease occurs among cattle (*woody tongue*) caused by the ingestion of certain forms of grass, in which the fungus exists. Man is infected through grains of barley and other cereals, or occasionally direct from a diseased animal. Persons most liable to the actinomycotic infection are stablemen, agricultural labourers, corn dealers, or others whose trade is connected with grain.

The micro-organism usually enters the human tissues by a lesion in one of the mucous membranes:—(1) Through the mouth *viâ* an abrasion in the mucosa of the cheek, through a tooth socket or tonsil; this is the commonest primary focus. (2) Through the bronchi, by inhalation. (3) Through the alimentary tract—the stomach and small intestine escape as a rule; the cæcum, ascending colon, and appendix most commonly become involved. The skin may be primarily infected, but as a rule is secondarily invaded by direct spread from one of the above lesions.

The lesion produced in any of these situations has definite characteristics. There appears a small area of granulation tissue, surrounded by a very dense and wide area of fibrous tissue, almost suggesting tumour formation. Subsequently a number of softened areas appear, purplish in colour; these break through the surface, forming sinuses at several points. Sometimes these heal leaving dense cicatrices, but more commonly they persist, and the condition slowly progresses. Secondary infection with other micro-organisms frequently occurs.

The material exuded from the abscess cavities and the sinuses has a curious yellow mucoid appearance, and at first sight may not present any other special feature. If, however, the clinical conditions suggest the diagnosis of actinomyces, some of this material should be placed between two slides and held up to the light, when a number of small soft bodies, the size of a pin's head, quite clear and translucent, will be observed. These bodies are spoken of as the actinomycotic granules. Characteristically these bodies will be observed as golden-yellow or black structures similar to those above described, except in colour; as a rule, however, these do not make their appearance until the sinus has been discharging for some time; they may be gritty in consistency. The granules are composed of a large number of filamentous structures matted together into a mycelium; occasionally the filaments remain free and thus granules are not seen. Typically, around the edge of the granules there is a vertical striation giving rise to a palisade appearance; this is due to the arrangement of the terminations of the sheaths which the filaments possess ("clubs").

To demonstrate the presence of actinomyces microscopically film preparations of the pus should first be examined in the fresh state and then stained by Gram's method, when a positive result will be obtained; an attempt may be made to grow the micro-organism on a suitable medium, *e.g.*, glycerin agar; it grows with difficulty. It is not pathogenic for animals other than cattle.

*Signs and symptoms of the disease.*—The disease is a localised infection as above described, running a chronic course associated with fever, marked anæmia, progressive wasting, signs of toxæmia, and most frequently, except in the case of mouth and face lesions, ending fatally either from the involvement of important structures, secondary infection with other micro-organisms and their sequelæ—pyæmia, bacteriæmia, or amyloid disease.

### *Local Lesions.*

*Mouth.*—This is the commonest focus of primary infection. A circumscribed area of inflammation with tumour formation around it slowly appears,

involving the jaw and floor of the mouth. The bone gradually necroses and forms sequestra. The skin eventually becomes involved, the infection slowly spreading at the edge down the neck towards the thorax, producing a sensation on palpation so hard as to give rise to the title of a "hide-bound" skin. At a number of points small nodules make their appearance which discharge pus, as above described. Stiffness of the neck, dyspnœa, trismus, and dysphagia supervene.

*Respiratory tract.*—It is said that in the respiratory tract the disease starts in the bronchi and from that situation spreads into the lung. The patient has an attack of chronic bronchitis or broncho-pneumonia, characterised by expectoration of very foul purulent material. On examination granules or threads may be found. More frequently, however, the condition is not diagnosed until the pleura becomes involved and an empyema forms which is opened or tracks through to the skin surface. In the latter event a large area of skin will become affected and a number of sinuses make their appearance.

*Intestinal tract.*—The patient will complain of a chronic form of gastro-intestinal disturbance characterised by attacks of diarrhœa, bleeding, and sometimes pus in the stools. The disease starts by the formation of a number of nodules under the mucous membrane of the cæcum, ascending colon, and appendix. These nodules ulcerate and eventually involve the peritoneum, causing dense adhesions and small localised abscess formations, which eventually fuse together to form a large abscess, often diagnosed and treated as due to appendicitis. The intestines become matted together, and communications may arise between neighbouring loops by ulceration; the anterior abdominal wall becomes characteristically indurated. This form of affection is prone to give rise to metastatic deposits, especially in the liver, where localised abscess formations arise surrounded by dense areas of fibrous tissue having the appearance of a honeycomb. The lymphatic glands draining the various infected areas are said never to become involved unless secondary infection with other bacteria has occurred.

The diagnosis depends on the recognition of a chronic inflammatory lesion characterised by tumour formation, tending to multiple abscesses and sinus formation. The progressive nature of the lesion is a feature worthy of note; the exact diagnosis, however, depends on the finding of granules or threads in the pus.

*Treatment.*—As in all chronic infections, fresh air, sunlight, and good nourishing food are essential. The first line of treatment is solely operative. As soon as the cause of the lesion is diagnosed by bacteriological investigation the focus of infection should, if possible, be removed. This is possible in the case of the mouth and jaw lesions, and occasionally in cæcal and appendicular involvement. Unfortunately the patients do not as a rule come under treatment until it is too late to carry out such measures.

Under these circumstances the abscesses should be opened, and as far as possible the affected structures should be scraped or excised; packing with iodoform gauze and the local application of strong antiseptics—*e.g.*, iodine and carbolic acid—are advised.

At the same time large doses of potassium iodide varying from 60 to 200 grains a day should be administered, it being said that the drug is specific for streptothricial infections.

Vaccine therapy has been tried in a few cases with good results, but it is essential to utilise an autogenous agent, it being impossible to certify that a particular lesion is dependent on a specific micro-organism. The dosage corresponds to that used in the case of tuberculin.

## Glanders.

The disease due to *B. mallei*, when it affects man, is known as glanders; it more commonly affects animals—horses, mules, and asses—amongst whom there are two types of disease, termed *glanders proper* and *farcy*.

*The disease in animals.*—*Glanders proper* is an acute condition, occurring as an inflammation of the nasal mucous membrane with subsequent ulceration, producing a profuse blood-stained discharge. It speedily disseminates through the body, producing pyæmic abscesses.

*Farcy* is a more chronic condition characterised by a localised ulceration of the skin at the site of inoculation. The lymphatic vessels draining the area stand up as thick cords (*farcy pipes*) and the lymphatic nodes are greatly enlarged (*farcy buds*). This is prone to disseminate in a similar manner to the acute condition.

*The disease in man.*—Man is most commonly affected through his occupation, which leads him to come in contact with infected animals—grooms, ostlers, cattle drivers, coachmen, blacksmiths, and carters are the more likely persons; bacteriologists working with the micro-organism have frequently been infected.

The incubation period is from three to eight days, but may be much longer. Two types of infection occur—the *acute* and the *chronic*.

*Acute glanders.*—The micro-organism gains entrance to the body either through the nasal mucosa or by direct inoculation through the skin. The condition is characterised by (1) an infective lesion as apple-jelly-like nodules at the site of inoculation, with rapid glandular enlargement; (2) a profuse, foul-smelling, sero-sanious nasal discharge, later becoming purulent and associated with enlargement of cervical glands; a similar condition affects the pharynx, larynx and trachea; (3) a pustular eruption on the skin, especially that of the face; (4) enlargement of lymphatic nodes with suppuration and ulceration on to the surface; (5) numerous intramuscular tumefactions, which break down and discharge foul-smelling pus; (6) dissemination to internal organs either as a bacteriæmia or pyæmia, usually involving serous cavities, liver and spleen, bone-marrow, salivary glands, lungs, etc., resulting in death, three weeks from the onset of the infection; (7) constitutional symptoms; during the earlier stages, those of an acute febrile condition, frequently with rigors and delirium, and later, passage into a typhoid state.

Recovery from this condition is very rare.

*Chronic glanders* is characterised by the appearance of a chronic ulcer at the site of infection, usually on the skin of the hands, face, or palate, extending deeply into the tissues, and having ragged, irregular, undermined edges, and a sloughing base from which an exceedingly foul-smelling discharge exudes. Multiple lesions are characteristic. Glandular enlargement is usually present. Deposits also form in the subcutaneous tissues and muscles. The condition is much less rapidly progressive, often extending over many months, but is liable to turn into the acute form of glanders. The prognosis is almost as grave, but recovery is more frequent.

The diagnosis is confirmed by the recognition of the *B. mallei*, which are minute, straight rods, with rounded ends, without flagella or spores. They stain irregularly with the ordinary dyes and with some difficulty, and are Gram-negative. They are difficult to find in pus, especially in the chronic lesions. A characteristic cultural appearance can be demonstrated on glycerine potato when yellowish colonies, speedily turning a chocolate-brown colour with green edges, make their appearance.

Agglutination tests are of service.

Straus's test, which consists in the introduction of material or pus derived from a suspected lesion into the peritoneal cavity of a male guinea-pig, resulting in the production of a suppurative orchitis, is confirmatory evidence. In animals the disease is recognised by inoculations of a vaccine called "mallein," prepared from glycerine broth cultures. The production of a local swelling and a rise of temperature is regarded as diagnostic.

*Treatment.*—Avoidance of infection must be observed and isolation of the infected is essential; infected animals should be slain. There is no treatment of any avail. The ulcerative conditions should be dealt with on general principles. The actual cautery is sometimes beneficial; abscesses are painted with mercurial salts or zinc chloride.

Blood infection is the most characteristic feature of the disease, and up to the present time there is no evidence that any form of vaccine or serum is of the slightest value. The use of mallein should be tried.

Arsenic, iodine, and creosote administered internally are used as specific drugs.

## Tetanus.

The disease resulting from infection by the *B. tetani* is a toxæmia characterised by a condition of tonic and clonic spasms of the voluntary muscles due to the action of the toxins, which are manufactured at an initial focus of injury. The disease is not commonly met with in this country in human beings, but is more frequently seen in tropical regions, especially among horses, often in an epidemic form. As met with in man the sources of infection are numerous and depend for the most part on the presence of a wound, usually of a punctured character, which has become contaminated with soil, street earth, or dung, in which the bacillus can generally be found. The disease is most commonly associated with injuries resulting from street accidents, in charwomen who run splinters into their hands in scrubbing floors, in gardeners, stablemen, and others whose occupation brings them in contact with the earth. In war-time pieces of broken shell carry earth-soiled clothing into the wound; in former days bullets had a similar effect, but at the present time those in use are much smaller in size and are not so liable to carry the clothing with them.

Tetanus is prevalent among horses, who become infected through their hoofs; those whose duty it is to perform post-mortem examinations in veterinary hospitals are thus liable to infection; laboratory experimenters occasionally become inoculated.

Owing to difficulties in sterilisation, catgut when first introduced as a ligature material in surgical operations proved a source of infection, and similarly the inoculation of gelatin into aneurysmal sacs had the same effect. In these days, however, tetanus is a rare complication of surgical operations.

In tropical climates tetanus occurs in infants as the result of infection from the umbilical cord, and also in women after childbirth *viâ* the uterus, both lesions probably resulting from uncleanly technique; conditions so arising are known as *tetanus neonatorum* and *tetanus puerperalis* respectively.

*Types of disease in relation to prognosis.*—There are two types of the disease, depending on the time of the onset of the symptoms from the date of the initial injury. The incubation period varies from twenty-four hours to one month; broadly speaking the tenth day can be taken as that which divides the two groups. Those in which symptoms make their appearance before that date are spoken of as *acute* cases and must be regarded as grave and extremely liable to

a fatal issue, whereas those occurring after that date and spoken of as *chronic* cases are more prone to recover spontaneously. In other words, the definition is one of importance as regards prognosis, for the earlier the onset of symptoms the more frequently will the result be fatal.

*Symptoms and signs.*—A wound showing evidence of suppuration can usually be found, but often a scar only is present, the original lesion having been so trivial as to have healed completely prior to the onset of symptoms; occasionally no wound at all can be seen; this can be explained possibly by the fact that the injury has occurred through a mucous membrane. The patient complains of stiffness of the neck, inability to open the mouth (*trismus*), and difficulty in swallowing. This stiffness extends to the other muscles of the body until finally those controlling respiration become involved. The patient also complains of extremely painful spasmodic twitching of the muscles, excited by such trivial external stimuli as the shutting of a door or the draught from a window. On examination the muscles are found to be in a state of tonic contraction, rendering them quite rigid. If they are touched, clonic spasms supervene, rapid in character and extremely painful. As the infection proceeds the spasms become more intense and more easily respond to external stimuli. The masseter muscles are those most commonly affected, rendering it impossible for the patient to open his mouth (hence the term *lockjaw*). The muscles of the face become contracted, giving rise to a typical appearance known as *risus sardonicus*. The abdominal muscles become rigid and may draw the body forwards (*emprosthotonos*). The back muscles may become so contracted as to approximate the head and the heels (*opisthotonos*), and occasionally lateral bending is observed (*pleurosthotonos*). In the later stages, the muscles of the extremities become similarly involved; and lastly, the muscles of respiration, the intercostals, and the diaphragm are included. It is at this stage that the patient dies from respiratory embarrassment if spasms of the epiglottis and exhaustion have not previously caused death.

The temperature is seldom raised above 100° F. until the final stages, though at any stage hyperpyrexia may supervene. The pulse varies with the spasms. Profuse sweating is a characteristic feature. The urine is high-coloured and concentrated. The bowels are obstinately constipated. The patient is unable to sleep and retains consciousness until the end; very seldom indeed does delirium appear. The expectant fear of a spasm is very distressing.

*Diagnosis.*—The diagnosis of the condition in the advanced stages is not difficult to make. Tetanus has to be distinguished from any condition in which general spasm of voluntary muscles takes place, especially hydrophobia and strychnine poisoning. In both of these the spasms are clonic in character. In the former there is a history of a bite by a rabid dog or fox, and the muscles affected are those of respiration only; moreover, delirium is a prominent symptom. In the latter the muscles of the limbs are affected at an earlier stage than those of the facial group.

Trismus may be the only evidence of tetanus at the onset of the condition. Care should be taken to exclude such peripheral causes as a carious tooth, oral sepsis, parotitis, and inflammatory lesions of the cervical lymphatic glands. Rigidity of the muscles of the neck may suggest the presence of some form of cerebro-spinal meningitis. An examination of the cerebro-spinal fluid as obtained by lumbar puncture will help in the differentiation.

In making the diagnosis of tetanus any wound, especially of a punctured character, which has been contaminated with the earth should be suspected as being liable to infection with the bacillus and investigated accordingly.

*Recognition of the bacillus.*—The material for examination should be taken from the depths of the wound, scrapings with a spoon being resorted to, if necessary. Film preparations should be made in all cases, for cultural evidence of the disease may not be obtained. The bacillus, which was first described by Kitasato, is slender, long, with a terminal spore at one end, which appearance gives to the micro-organism the title of the *drumstick* bacillus; it has flagella, but is only feebly motile. With the exception of the spore, which requires special methods, it stains quite readily with the ordinary dyes, and by Gram's method. On cultivation it will not grow unless placed under anaerobic conditions; even then its isolation is one of extreme difficulty, owing to the invariable presence of other bacteria in the lesion.

A more rapid method of demonstrating its presence consists in the inoculation of some of the suspected material into the back of a mouse near its tail; that appendage becomes rigid within a few hours and the animal dies with typical tetanic spasms within twenty-four hours.

*Pathology of tetanus.*—In the treatment of tetanus a knowledge of the mode of action of the bacillus is essential. It acts by virtue of its toxin, which is composed of two parts—*tetano-spasmin*, which is responsible for the muscular contraction, and *tetano-lysin*, which produces hæmolysis. The bacillus remains localised to the initial site of infection, and can at no time be found apart from this either during life or after death. Its toxin is absorbed by the lymphatics which run in the motor nerve sheaths, and by this means is carried to the central nervous system. The toxins fix on to the cells of the grey matter in the upper part of the spinal cord and the medulla, causing them to degenerate, at the same time producing a dilatation of the vessels of the part and other evidence of inflammation.

There seems to be some selective action by the toxin for the muscles which control the face and neck in man, although this is not the case in other animals. In the post-mortem room there is very little evidence of disease to be found beyond the microscopical changes above indicated. A hæmatoma among the muscles may be found, resulting from a rupture caused from the violent contractions. The cerebro-spinal fluid and emulsions of brain or nerve tissue, when introduced into the mouse, will produce typical lesions.

*Treatment.*—The principles of treatment come under four headings—

1. Prophylaxis.
2. Elimination of the toxin.
3. Neutralisation of the toxin.
4. Relief of symptoms.

1. *Prophylaxis.*—Any wound that is contaminated with earth, dung, etc., should be regarded as a possible site of infection for *B. tetani* and should be dealt with accordingly.

In the first place attention should be given to the wound. All foreign material should be removed from it, including any tissues that may be devitalised as a result of the injury. Punctured wounds should be freely laid open. Provided that the damaged tissues can be freely excised, primary suture should be performed; but if for any reason it is impossible to carry this out, *e.g.*, excision demanding removal of vital tissues, the wound having been freely laid open may be packed with gauze soaked in flavine or other suitable antiseptic and submitted to either delayed primary or secondary suture. A careful examination should be made for the presence of the bacillus of tetanus.

The most important detail of the prophylactic treatment consists in the introduction of anti-tetanic serum, which has, as its object, the neutralisation

of any toxins that may get into the blood-stream, and thus prevent their attachment to the cells of the central nervous system.

The anti-toxin should be introduced as soon as possible after the injury, and will be most effective if given within the first twenty-four hours. Unfortunately, in civilian practice this is not often possible, especially in the case of minor injuries, as the patient fails to attend for treatment until the first symptoms of tetanus have manifested themselves.

It is as a rule a sufficiently reliable route if the serum is introduced into the subcutaneous tissues; there is no necessity to use, as the site of injection, the neighbourhood of the wound.

The amount introduced varies from 500 to 1,500 U.S.A.* units (in 10 c.c.). The more extensive the wound, and the longer the delay after injury, the larger should be the initial dose. The effect of this dose rapidly passes off, so that further doses of 500 units should be introduced every fourth to seventh day. Four doses are sufficient.

The use of this method has been amply justified by the experience of surgeons during the war. Prior to the introduction of serum therapy as a routine measure numbers of fatal cases of tetanus were seen, whereas later, not only was it rarely observed, but when it did appear, it was only in a mild form characterised by spasms localised to the muscles in the neighbourhood of the wound (*local tetanus*).

Local tetanus seldom led to serious results, although it occasionally developed into the generalised type in modified form. This form of the disease has been known to appear many months after the injury, even after the wound had healed; this led to the repetition of injections mentioned above; a few cases occurred even after this procedure.

Tetanus again has been recorded as a post-operative sequel when it has been requisite to open up a wound months after the injury, although no symptoms of the disease had previously shown themselves (*delayed tetanus*), thus emphasising the necessity of giving prophylactic injections preceding the opening up of earth-infected wounds.

The only troublesome sequela of serum therapy is the appearance of serum disease.

(2) *Elimination of the toxin.*—An attempt should be made to do this by the institution of free diuresis, by giving large quantities of fluids to drink, and even by the use of drugs. The bowels should be freely purged. It is seldom that diaphoretics are necessary, as free sweating is common as the result of the spasms. Intravenous and rectal injections of saline solutions are strongly indicated.

3. *Neutralisation of the toxin in declared tetanus.*—Some cases of tetanus are not so severe as others and it is possible to deal with such even when the disease has manifested itself. The mortality, however, is extremely high at whatever stage the disease is met with and whatever form of treatment is adopted.

The wound should receive similar attention to that already described in dealing with the case before evidence of infection has arisen, but there is no advantage in carrying out such heroic measures as amputation.

*Serum therapy.*—Behring was the first to point out the value of anti-tetanic serum, as he observed it during animal experimentation. Unfortunately the use of these agents in the treatment of the disease is disappointing, the toxin having already become fixed to the cells of the central nervous system. It is only possible to neutralise the effect of fresh free toxin by the introduction

* Forty U.S.A. units are equivalent to one Behring unit.

of anti-toxin. However, serum therapy should always be tried in the hope of avoiding a fatal result. The various methods of injecting the serum are as follows :—

(1) *Subcutaneously.*

(2) *Intramuscularly.*—More rapid absorption than by subcutaneous method.

(3) *Intravenously,* mixed with saline solution. This method is more rapid and more likely to reach the central nervous system.

(4) *Intraneurally.*—The method is suggested as a recognition of the route of absorption of the toxin. If this route is selected the anti-toxin should be introduced into the nerve as near the spinal cord as possible.

(5) *Intradurally,* either by the spinal route or directly into the skull. A corresponding amount of cerebro-spinal fluid should be withdrawn prior to the introduction of the serum.

(6) *Intracerebrally.*—A small hole is bored through the skull over the vertex of the brain and the serum is introduced directly into its substance. As this is some distance from the medulla there is doubt as to its value, and it is suggested that a better site would be directly into the spinal cord ; in this case, however, hæmorrhage is likely to occur.

Whichever of these routes is utilised it is advocated that large doses of the serum should be given.

Many schemes of treatment have been suggested, the following is an example :—

(*a*) Inject as soon as possible after the onset of symptoms 3,000 to 5,000 U.S.A. units intraspinally, after withdrawing cerebro-spinal fluid, the serum being diluted with a small amount of sterile normal saline in such volume as to correspond with the amount of cerebro-spinal fluid withdrawn. A very much larger number of units may be introduced if the serum can be obtained in concentrated form, *e.g.*, 25,000 units in 10 c.c.; 10,000 to 15,000 units intravenously, intramuscularly or subcutaneously should be given at the same time.

(*b*) 3,000 to 5,000 units intraspinally daily, combined with a similar dosage by either of the other three routes mentioned. The intraspinal injections should be given while the patient is under an anæsthetic. These mounts can be gradually reduced or increased as changes in the symptoms indicate, and be carried on until such time as the symptoms abate.

*Bacelli's method.*—Carbolic acid has the effect of destroying the tetanus toxin, and at the same time has the advantage of being rapidly absorbed when given into the subcutaneous tissues : 1 c.c. doses of 1 per cent. solution of carbolic acid are administered every two hours or even more frequently during the day until 80 grains per diem have been introduced.

*Injection of brain tissue.*—Tetanus toxin has an affinity for brain tissue. Inoculations of an emulsion of fresh brain into the subcutaneous tissues of the affected person are thus suggested : 10 grammes of fresh brain are made into an emulsion with 30 c.c. of sterile saline solution and used for this purpose.

4. *Relief of symptoms.*—The spasmodic contractions of the muscles are most distressing, and may be relieved by giving large doses of chloral, bromides, atropin, or morphia. An injection of a solution of magnesium sulphate, in doses of 5 to 10 c.c., into the spinal theca acts by inhibiting afferent and efferent impulses to and from the central nervous system. Injections of eucain by this route have a similar effect. The avoidance of all external stimuli such as noise, draughts, and touching of the bed of the patient is essential. If the spasms become excessive chloroform may be required. Pain is relieved by

the use of chloral and paraldehyde. In trismus, feeding is difficult; the use of nasal tubes, removal of the teeth, and the passage of œsophageal tubes or rectal enemata may have to be resorted to.

## Infection by Anaerobic Bacilli.

These bacilli are responsible for lesions characterised by the appearance of rapidly spreading gangrene, associated with the formation of gas in the tissues and intense toxæmia.

The disease due to these bacteria is variously called *acute spreading traumatic gangrene*, *emphysematous gangrene*, *gas gangrene*, and *malignant œdema*. In association with these organisms the *B. coli communis* and *streptococci* are frequently found. Infection in a large majority of cases is a mixed one. The micro-organisms are extremely numerous in highly fertilised soil, fæces of animals and of human beings. They are strict anaerobes and may be divided into two groups, as follows :—

(*a*) Saccharolytic group, which decomposes carbo-hydrates with production of acids, carbon-dioxide and hydrogen gas.

(*b*) Proteolytic group, which digests protein, producing ammonia, with power of splitting sugars.

The classification of these micro-organisms as a result of experience during the war has become more complete. Into the former have been placed : *B. Welchii*. *Vibrion septique*. *B. œdematiens*.

Into the second group, *B. sporogenes* and *B. histolyticus*. The two latter are non-pathogenic.

*B. Welchii* is the most important.

These bacteria have the most marked effect in tissues which have been so severely damaged as to become necrotic; they are seen in connexion with severe crushes, compound fractures, and punctured wounds contaminated with dirt, *e.g.*, bullet wounds. The retention of foreign bodies in the wound strongly favours the production of the infection. The resultant effect on the tissues varies, depending largely on the depth of the original wound; various clinical types are recognised.

1. The inflammatory process may be localised to the region of the primary site of the infection and affect only the subcutaneous tissues.

2. It may spread along the interstitial planes and disseminate along the course of nerves and give rise to an intermuscular lesion.

3. The muscles may become involved either singly, in groups or involving a whole limb.

This last condition is the one most commonly seen in the so-called "*gas gangrene*" of war surgery.

The resultant effect in all types is production of gas in the tissues with exudation of fluid causing softening, disintegration and subsequently complete necrosis.

The changes seen in the muscle are characteristic. At the site of the injury the tissue is black, soft and diffluent. Around this and separated from the healthy muscle by a line of demarcation is a pale red area. As the disease spreads the colour changes to a dirty red, green and black, the whole becoming soft, and gas bubbles forming in between the fibres. One of the early signs of change in the muscle is its loss of contractility when pinched. The gas formation may not be obvious in the early stages. The intermuscular tissues also become filled up with serous fluid, and the fat has in it areas of an orange colour, which are quite characteristic. In the more

advanced forms, especially when the *vibrion septique* is the cause of the lesion, there are large blood-stained areas found in the tissues.

Occasionally in the localised type an abscess containing gas forms, but this is uncommon.

*Symptoms.*—The onset of the disease is usually exceedingly rapid, but may be delayed for some considerable period after the time of injury.

Vomiting is one of the earliest symptoms, and when associated with an earth-infected wound, together with a sudden rise in the pulse-rate, pain in the limb, raised temperature and restlessness, should be regarded with grave suspicion. The face assumes an earthy pallor. A sweet odour is noticed quite early.

In the massive types of infection the patient may in a few hours change from an apparently healthy condition into a state of extreme collapse. On examination, the limb will be found to be exceedingly tense and the muscles to be quite firm. The skin, with the exception of the appearance of blistering on the surface, is not obviously changed; in the early stages there is no evidence of gas formation. Later the skin becomes red, black or green; subsequently crepitus, characteristic of interstitial emphysema, is found on palpation. The limb rapidly swells, and if a wound is present, pale, blood-stained, thin serous fluid runs out in large quantities. There may be no discharge of pus. On percussion over the limb a tympanitic note may be elicited if gas is present to any extent, especially if in a localised area. Gas areas are demonstrable by X-ray photography.

The progress of the disease varies largely with the type. If suitable treatment is carried out in the localised form the patient may recover, but if it passes on to the massive fulminating type, death will take place within forty-eight hours.

Confirmation of the disease, if needed, other than by the clinical signs, depends upon the demonstration of anaerobic bacilli in the discharge or in the blood-stream.

In the post-mortem room the anaerobes will be found in many of the viscera, which will be shown filled with the gas bubbles, producing, for example, such conditions as "foaming liver."

*Treatment.*—Every wound that is earth-soiled should be regarded as possibly infected with anaerobic bacteria. The treatment consists both in prophylactic and active methods. As regards prophylaxis, the most important treatment consists in the mechanical cleansing of the wound, the thorough excision of all completely and partially devitalised tissues and the removal of any collection of blood, for the latter frequently plays an important part in the spread of the disease, and is usually associated with it. Alkaline washes of hydrogen peroxide continually run into the wound are efficacious. This type of lesion lends itself admirably to treatment by Carrel's method, if efficiently carried out.

In the case of localised lesions, especially if only involving subcutaneous tissues in the neighbourhood of the wound, early and free incision may be all that is necessary, combined with efficient after-treatment and careful watching for any spread of the disease. When it is suspected that it is spreading into the intermuscular or muscular tissues, it is obvious that more radical methods are required. The wound should be freely opened up, all damaged tissues should be removed and observations confirmed; bacteriological examination should be made along the whole of the course in the suspected tissues. If it has spread into a muscle, the whole of that muscle must be regarded with suspicion, and if there is any reason to believe that a part of it is involved, that muscle or the group of muscles should be excised. If, however, it is

more extensive, amputation is the only possible course to adopt. When such an amputation is performed the stump should be left freely open and exposed and some suitable method of after-treatment adopted, such as the use of Carrel's method, the application of flavine or hydrogen peroxide packs. This may be followed later by delayed primary suture, but often it is better to await a secondary suture.

When the patient has reached the condition in which the general symptoms are marked, no attempt at local excisions should be attempted, but amputation performed straight away.

The level of the amputation is important, and in deciding this point it must be remembered that the disease spreads in a longitudinal fashion up the limb.

So far as the general condition is concerned, the treatment carried out in other infective conditions is important. In addition it has been found useful to give the patient intravenous injections of sodium carbonate. There is no evidence that an antiserum is of any value. Intravenous infusions of saline in order to provide fluids to the body should always be given.

## Rabies.

Rabies or hydrophobia is a disease which usually terminates fatally, and is due to a virus about which little is known. No specific micro-organism has been discovered, either in film preparations or in cultivations. It affects dogs, wolves, foxes, and man, and is transmissible by the saliva. Man is usually infected by a bite or scratch on exposed skin surfaces with the tooth of an affected animal. Clothing acts as a protective. The local lesion may heal completely before symptoms of the disease manifest themselves. The incubation period varies from two weeks to many months or even years. Six weeks is a common time. The toxin is absorbed by the lymphatics of the nerve sheaths and carried to the central nervous system, in this way resembling tetanus. It is never found in the blood or other tissues of the body, except possibly the bronchi and the mammary gland.

In the post-mortem room there is little evidence of disease beyond the appearance of subpial hæmorrhages on the surface of the brain and some myelitis, especially in the region of the pons. The diagnosis can only be completed by inoculating portions of the central nervous system into dogs or rabbits, with the production of hydrophobia in a week or fortnight.

*Symptoms.*—The local symptoms of an infected wound occur at the site of the bite. This may heal, but preceding the general infection a pricking sensation occurs in it. After a variable period the patient complains of headache, restlessness and anxiety, becomes melancholy, desires to be by himself, and often has hallucinations ; delirium is a prominent symptom. This is followed by painful spasmodic contractions of the muscles of the jaws, pharynx and larynx induced by attempts to swallow ; even the sight of food, either liquid or solid, draughts, sudden noise, *e.g.*, the sound of running water, have a similar effect. The patient frequently bites anything accessible.

Long intervals of peace intervene under suitable conditions. After two or three days a paralysis of the pharyngeal muscles comes on, which lasts for about twelve hours, the patient dying of asphyxia due to involvement of the respiratory muscles.

The condition must be distinguished from that occurring in hysterica persons after they have been bitten by uninfected animals; these cases recover.

Sometimes the paralytic symptoms appear from the time of onset of the infection, the patient dying rapidly. This is often spoken of as *dumb rabies*. In dogs the animal first becomes dumb and hides in dark places; later he becomes excited, rushes about snapping at other dogs or human beings, and is ravenously hungry, eating anything. This is followed by paralysis of the pharyngeal muscles, so that he is unable to drink; he howls miserably, and dies from failure of respiratory action. The disease usually lasts for three or four days.

*Treatment.—Prophylaxis.*—Immediate attention should be paid to a bite produced by an animal suspected of being infected; the wound, if possible, should be treated by excision, combined with the application of the thermo-cautery, pure carbolic, silver nitrate, or pure nitric acid.

*Treatment of lesion.*—Excision, when the symptoms have appeared, is not of much value, as the toxin has already passed up to the central nervous system *viâ* the lymphatics in the nerve sheaths. Immunisation by Pasteur's method should be introduced. It consists in the subcutaneous introduction of a vaccine in daily doses. The vaccine is prepared from the dried spinal cords of rabbits infected by the virus. The virus is attenuated by drying; the longer the cord is dried the greater is the attenuation of the virus, and *vice versâ*. Inoculations are started with cords dried for fourteen days and increased up to those dried for three days only. The daily inoculations are continued for a fortnight. An intensive method starting with a stronger dose is also in use. The mortality of the disease has been reduced by this means from 10 per cent. to 1 per cent.

A serum obtained by immunisation of sheep with attenuated virus is advocated by Italian observers. Doses of 10 c.c., 5 c.c., and 5 c.c. on three successive days are advised. Marie has more recently prepared a sensitised vaccine by placing the virus in contact with antirabic serum.

### Infections produced by Parasitic Worms.

**Filariasis.**—The tropically endemic inflammations and obstructions of the lymphatics which give rise to chyluria, chylous hydrocele and ascites, lymphocele, also to lymphangitis, cellulitis, and lymphorrhagia resulting in elephantiasis, are due to the presence of the worm, *Filaria sanguinis hominis nocturna*, in the lymphatics and glands. The worm is inoculated by means of the mosquito, *culex fatigans*, and passes thence to the lymphatics of the trunk, where masses of the worms, each about 75 mm. in length and of both sexes, are found in the tributaries of the thoracic duct. The young embryos escape into the lymph stream and enter the circulation through the thoracic duct late in the evening. If a drop of blood be taken in the evening before midnight, and examined either wet, or as a film dried and stained with methylene blue, numerous embryos about 0·3 mm. in length will be found. It is not known where these embryos rest by day, nor why in some cases an inflammation is set up, whilst in others the presence of the worms gives rise to no disturbance. Manson's theory of the intermittent attacks of fever to which the patients are subject is that they are due to abortion by the female parasite of immature embryos.

*Chyluria.*—The urine has a milky appearance, generally clots and settles into three layers, the upper whitish and fatty, the middle pinkish-red containing fibrin, the lowest reddish from blood débris. In it embryo filarias are found. The urine contains a large amount of albumin. Chyluria is usually connected with the presence of the parent worms in the commencement of

the thoracic duct, and may co-exist with a peritoneal or pleural chylous exudation.

*Lymphocele and lymphadenocele* consist of varicose lymphatics and enlarged inguinal and femoral lymphatic glands. The enlargement occurs about puberty, the swellings being partly solid and partly cystic, containing chylous fluid. The swellings are reduced by pressure and on lying down, and enlarge again on standing. They are subject to recurrent attacks of inflammation, resulting from the irritation of the contained worms. Sometimes they subside, sometimes a chylous fistula forms; in many cases elephantiasis slowly develops.

*Elephantiasis* affects the legs, scrotum and prepuce; in the female the labia and clitoris, also the breast. In Fiji localised patches of the skin develop into pear-shaped tumours. The complication commences by an attack of lymphangitis resembling erysipelas, with acute fever often ushered in by a rigor. The fever subsides in a day or two with profuse sweating, or even a discharge of lymph from the skin, and some thickening of the skin and subcutaneous tissue is left. A second attack soon follows, with increased thickening of the skin, which becomes gradually more and more rugose. The skin and subcutaneous tissue are enormously thickened by spongy, œdematous connective tissue, with dilated lymphatics and veins. Fistulous sinuses discharge lymph; septic ulcerations favour the recurring attacks of inflammation, and the patient suffers more and more from septic absorption and exhaustion.

**Filaria medinensis,** or the **Guinea worm,** is met with in India and Southern Asia, also in tropical Africa and America. The embryos develop in a fresh-water *cyclops*, and so gain entrance into the human intestine. The worm develops in the subcutaneous and intermuscular tissue, but passes unnoticed until it has reached the length of about six feet, and has drilled its way head first downwards to the leg, ankle or foot, where a bulla and then a superficial ulcer form. On contact with water a mass of wriggling embryos are discharged, each about half a millimetre in length, which have been followed into the *cyclops*. In addition to the bulla and ulcer the worm may be felt beneath the skin, and may give rise to an urticaria with vomiting. When the worm is broken up in the tissues, an acute multilocular abscess with sloughing and fever follow. The older method of treatment was to allow the worm to empty itself, for then it begins to emerge spontaneously, when its body as it emerges can be twisted upon a match, a little every day, without rupturing it. When felt distinctly coiled up beneath the skin it has been carefully cut down upon The safest way is to inject perchloride of mercury, 1 in 1,000, into the track of the worm, which kills it, and it is absorbed without local or general inflammation. Sometimes it dies spontaneously and undergoes a calcareous change without piercing the skin.

**Bilharziosis.**—This is an affection caused by a trematode worm known as the *Bilharzia hæmatobia* or *Schistosomum hæmatobium*. It is endemic in certain parts of the world, especially Egypt and South Africa, and produces symptoms of varying severity in different localities.

It is believed that infection takes place through the skin or mucous membranes in the region of the anus and urethra, and arises after prolonged immersion for bathing purposes in infected rivers or pools. The incubation period varies from three to six weeks. It is most frequently found in men and boys, and not in women.

The male worm is 1 cm. long, and the female about double that length. After penetration into the body the worm occupies the smaller branches of

the portal vein, and from thence travels to the veins in the submucous tissues of the bladder and the rectum. The eggs, after deposition, penetrate the mucous membranes of the bladder and the rectum, and are found in the urine and fæces. The ova are elliptical, with a sharp-pointed spine at one end. The length of life of the worm is unknown, but, after infection, and in the absence of re-infection, symptoms will persist from upwards of three to ten years.

The *symptoms* are painless hæmaturia and bloody mucoid stools. They may be associated with those of cystitis, or even calculus formation, for phosphatic deposits are apt to form around the site of the lesions which are produced. On examination of either the fæces or the urine, the ova can be readily found under a microscope. On examination of the bladder with the cystoscope, small bodies of a golden yellow colour are found projecting on the surface of the mucous membrane ; these are usually arranged in groups, and

Fig. 4.—Bilharzia ovum. (Drawing by Dr. W. Lazarus-Barlow.)

Fig. 5.—Bilharzia embryo. (Drawing by Dr. W. Lazarus-Barlow.)

may resemble the lesions seen in tuberculous cystitis ; they are, however, much larger, and the zone of inflammation around them is usually less marked. Little areas of granulation tissue, often amounting to papillomatous outgrowths, are sometimes seen (see Plate 36).

At the termination of the disease the bladder returns to its normal condition.

*Treatment.*—The treatment is largely prophylactic. Preventive measures consist in avoiding bathing in infected areas, and in the process of drying special attention should be paid to the regions of the anus and urethra. Circumcision is said to limit the liability to infection. Removal from a bilharzial country is obviously desirable.

Systematic treatment consists in the relief of the symptoms of cystitis.

Salvarsan has been injected as a specific for the disease, but there is no evidence that it is efficacious. More recently intravenous injections of antimony tartrate have been given, and by some are thought to be successful in killing the worm.

## Venereal Infections.

### Syphilis.

**Cause.**—Syphilis is an infective disease due to inoculation with *spirochæta pallida*, a protozoon or low form of animal life, whose relation to the disease was first pointed out by Fritz Schaudinn (died 1906) in the spring of 1905. The disease occurs most frequently in man, but it can be transmitted experimentally to anthropoid apes and a few of the lower animals. It resembles the other infective diseases in its general features, though it shows important differences, due perhaps to the fact that the majority of infecting micro-organisms are of a vegetable type, whilst the syphilitic microbe is protozoal. In accordance with the general rule of infective diseases syphilis has a seat of local inoculation; the inoculation is followed by a definite period of incubation; the incubation is succeeded by a train of signs which run a more or less orderly course, the later ones, in untreated cases, being more serious than those which first appear. The malady differs from the ordinary infective diseases in the tenacity with which the spirochætes cling to the tissues and the long periods during which the disease shows itself; by the intervals of apparent freedom from disease followed by fresh signs without farther infection; by the remarkable selective action of the spirochætes to produce changes in those tissues which are subject to the most prolonged strain; and, above all, by the undoubted fact that the spirochætes can be transmitted from mother to fœtus, so that the disease may be truly congenital. The infectivity of syphilis is very great in human beings, and it is doubtful whether any human body is proof against inoculation. A single attack does not confer immunity, but persons who have contracted the disease are proof against it so long as they are not cured—that is to say, so long as spirochætes are present in their tissues, a condition which may occur without clinical evidence of disease. Toleration is shown by nations, as well as by families, in which the disease has become endemic. The symptoms are milder, but such toleration is obtained at a price, for such nations and families are distinctly handicapped in the struggle for existence.

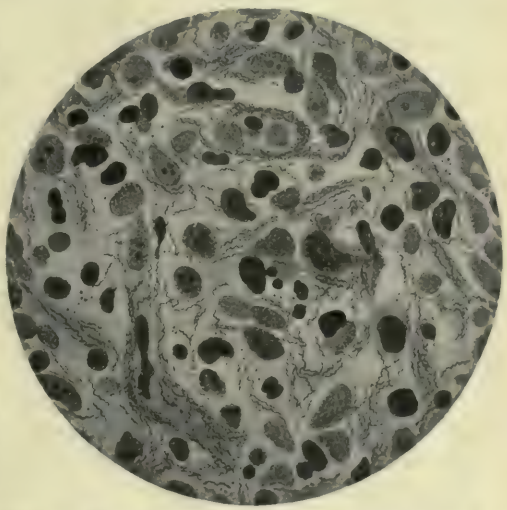


Fig. 6.—*Spirochæta pallida* in a section through a primary chancre of the penis, eight weeks after infection (Hoffmann).

**History.**—The disease appears to have been introduced into Europe within modern times, since the prehistoric and classical cemeteries give no unequivocal evidence of its existence in the remains which have been hitherto unearthed. Classical literature is devoid of any allusions to those signs of the disease which could hardly have been overlooked by such keen observers as the satirical poets, whilst the older medical writings, even as late as the fourteenth century, make no mention either of the symptoms or treatment of syphilis.

On the other hand, there is no doubt that syphilis was well known to the inhabitants of the New World when it was discovered by Columbus. The Peruvians had a curious facility in copying pathological details on their pottery, whilst their cemeteries exist in considerable numbers. Jugs as well as bones afford evidence of syphilis, but the disease seems to have been of a mild type, and was treated by herbs and woods. The introduction of syphilis into Europe occurred in 1493, and it spread rapidly from Spain into Italy, France, Germany, Holland, Greece, England, Scotland, Russia, and Hungary, presenting all the characters of an acute infectious disease attacking an unprotected population.

**Course.**—Syphilis is a venereal disease only in so far as it is often contracted during sexual intercourse. It may be inoculated on any part where an abrasion of the surface epithelium lays open lymph paths, which allows the spirochæte to gain access to the tissues. The seat of inoculation may thus be the lips, cheek, forehead, nipple, or fingers, although it is usually the penis, the vulva, or the os uteri.

**Incubation period.**—Inoculation with a pure culture of *spirochæta pallida* may pass almost unnoticed, as the abrasion heals without difficulty or delay. The infecting agent, on the other hand, is often a mixed culture of various pyogenic organisms, which may also contain gonococci and Ducrey's bacillus. The patient is thus inoculated with several micro-organisms, none of which are mutually incompatible. The existence of gonorrhœa and of soft sores is no evidence, therefore, that syphilis has not also been acquired, and as these diseases appear earlier than syphilis it is better to suspend judgment in all doubtful cases until further proof is obtainable. Formerly this could only be done by waiting until fever, enlarged lymphatic glands in the groin, a rash or mucous patches in the mouth proclaimed that a general infection of the body had taken place. Since Schaudinn's discovery of the causal relation of *spirochæta pallida* to syphilis it is not difficult to demonstrate the living spirochætes in sores which must otherwise have proved of doubtful nature, and whenever these organisms are present the treatment by an arsenical compound such as neo-salvarsan and mercury must be begun at once.

**Prophylaxis.**—Experimental evidence both in man and animals shows that the spirochæte infection is localised to the point of inoculation for a period measured by hours, and that, whilst it is thus localised, it can sometimes be destroyed by washing gently with soap and water, drying and afterwards rubbing in mercurial ointment to such an extent as to allow the mercury to be driven into the skin and lymphatics in the immediate neighbourhood of the affected part. The ointment employed is calomel 50, lanoline 90, and vaseline 10, and it should be well rubbed in for at least ten minutes. Such a method may be usefully adopted where a doctor or nurse has been knowingly exposed to the chance of syphilitic infection in the course of their professional duties, or where a healthy woman has unwittingly suckled an infant with an ulcerated mouth. Usually, however, the incubation period is allowed to run its course unobserved, because there is little to attract the attention of the patient. This period experimentally is twenty-one to twenty-eight days, but in exceptional cases it is as short as twelve days, or may be extended to sixty days. The average incubation in man is about thirty days, although similar variations occur in him as in apes and monkeys, for a sore has been noticed as early as ten days after infection and as late as sixty days. During this incubation period not much is to be seen; examination shows that the lymphatic glands nearest the seat of inoculation are becoming painlessly enlarged, and at the end of the period there is often some degree of fever.

The enlargement of the lymphatic glands is not great in patients inoculated simply with spirochætes, nor do the glands suppurate. They remain separate and are freely movable, so that they are described as being "shotty and discrete."

**Primary stage.**—Untreated and not irritated the incubation period ends with the appearance of "the chancre or primary sore," in the form of a small red papule at the seat of inoculation. This papule increases in size, and has an area of inflamed tissue beneath it which is known as the "indurated base." The amount of induration varies greatly, being most marked where there has been previous irritation. It is sometimes so slight as to pass unnoticed. The "primary or hard" sore thus produced does not show any marked tendency to ulceration if it is protected from injury and kept clean. It disappears spontaneously about ninety days from the date of infection—that is to say, about two months after its appearance—and it may be so inconspicuous and have caused such slight inconvenience that the patient may truthfully say that he never had one. More often, however, a mixed infection or accidental irritation causes the chancre to ulcerate. The induration of its bases is then a well-marked feature and its course may be considerably prolonged, whilst an indelible scar is left when it heals. The lymphatic exudation both from the ulcerated and the non-ulcerated chancre teems with spirochætes, and the hard sore, therefore, is acutely infectious

**Secondary stage.**—Towards the end of the hard sore—that is to say, about eighty days after infection—the patient begins to show signs of constitutional infection. These signs vary in number and intensity from a slight rise of temperature associated with anæmia and neuralgia to extensive rashes and much troublesome ulceration of the mouth. The rash, in its simplest forms, is so slight as only to be noticeable when the skin is viewed through a blue glass; more often it is so well marked and extensive as to cover the whole body. Occasionally when the skin is exposed to some unusual amount of irritation small ulcers are developed, so that even at this early period "gummata" may form, although they are usually said to be characteristic of the later stages of syphilis.

The chief secondary manifestation is connected with the mucous membranes, more especially of the mouth. White patches—"mucous patches or plaques"—appear inside the lips where the teeth rub, on the mucous surfaces of the cheeks, on the pillars of the fauces, and on the tonsils. These mucous patches—which must not be confused with the leukoplakia of a much later stage—are often painless, although they may be surrounded by a red inflammatory zone and may ulcerate, in which case the patient complains of a feeling of discomfort—the sore throat of secondary syphilis. Similar patches occur round the margins of the anus, on the vulva, and in the folds of the groin in uncleanly persons, and in these places they are called "condylomata," which individually are small, though they are usually multiple and fuse together to form raised patches which secrete an offensive discharge. The mucous patches, like the primary sores, are acutely infectious, and every patient should be warned of the fact, as it is by their means that syphilis is generally transmitted. Further a secondary lesion may take place at a later period—that is to say, within a year or eighteen months of infection—iritis and swollen testicle being two of the more common.

It is characteristic of the secondary manifestations that they yield readily to treatment and even tend to improve spontaneously. They are followed by a deceptive period of varying length, during which the patient seems to

be cured, as he may be free from all clinical signs of syphilis. The application of Wassermann's test, however, and the subsequent progress of the disease, show that he still harbours spirochætes in the majority of cases and that they will again become active under appropriate conditions.

**Tertiary lesions.**—When the patient has been efficiently treated no further signs of syphilis may occur so long as the patient remains in good health, even though the Wassermann test shows that he is not absolutely free from spirochætal infection. With increasing years, under debilitating conditions, whether of mind or body, and as a result of undue strain or irritation put upon some particular organ or tissue, the signs of syphilis often reappear even when the disease has remained latent for very long periods of time. More frequently inefficient treatment allows the disease to progress, and the more serious ulcerative lesions appear. These lesions pathologically begin as collections of small round cells known as " gummata," which show a marked tendency to undergo degenerative changes ending in ulceration, or to the formation of a lowly organised fibrous tissue which shrinks and distorts like scar tissue. The ulcers are conical, the apex of the cone lying deepest ; they are usually multiple, and they fuse by a simple process of extension to form larger ulcers, whose margins therefore are crescentic, whilst the base is formed by necrosed fibrous tissue of a consistency similar to wet wash-leather. When the ulcers heal, scars are left which have a characteristic helicoidal or " snail track " shape. Such ulcers are seen best in the skin and in the soft palate. In the skin they may be covered with crusts or scabs consisting of layer heaped upon layer like a limpet shell, whence the term " rupia " is applied to the condition. In the soft palate the destructive changes may lead to loss of the whole palate or to its perforation. Gummatous inflammation also occurs in the viscera and in the central nervous system usually within three or four years after infection, but ulceration does not occur, as there is no coincident infection with pyogenic organisms.

The sclerosing changes take place later and are found in the bones, where they lead to nodes and diffuse osteitis ; in the testicle, causing the small craggy testicle, and in the tongue leading to chronic glossitis with leukoplakia ; in the arteries as arterio-sclerosis, producing aneurysm, and in the liver giving rise to syphilitic hepatitis.

**Parasyphilis or parenchymatous syphilis** is an interesting form of the disease best known by its results—tabes and general paralysis. It presents several peculiarities as yet incompletely elucidated. It occurs later than gummatous inflammation, and most often about ten years after infection. The previous symptoms of the disease have usually been of a mild type. The progress is slow, but steadily to a fatal issue, usually from some intercurrent disorder. Treatment on the ordinary lines is ineffective. A similar condition occurs in the tongue, but at a later period than in the nervous system. In the nervous system the toxins or the spirochætes themselves act upon the neurones, and the formation of fibrous tissue appears to be a secondary result ; in the tongue the inflammatory result is shown by leukoplakic patches in the epithelial covering and by a sclerosing process in the intermuscular connective tissue. These changes often end in cancer of the tongue, more especially when the irritation is aggravated by smoking.

**Congenital syphilis.**—A man who marries whilst the spirochætes are active in his tissues frequently infects his wife and through her any child whom he may beget. The child thus infected suffers from congenital or hereditary syphilis, and its tissues contain spirochætes, which are necessarily derived from the mother through the placenta. Such children are often born dead

or the mother aborts about the end of the third month. When the child is born alive it may show definite evidence of syphilis by eruptions on the skin and by gummata of the viscera, more especially of the liver; or it may die shortly after birth from convulsions or marasmus. Sometimes these children are born in seemingly good health, only developing symptoms of syphilis three to six weeks afterwards—infantile syphilis. They become wizened, chronic inflammation of the nasal mucous membrane causes "snuffles," mucous patches appear in the mouth and condylomata in the folds of groins and buttocks, whilst the buttocks themselves present a characteristically raw and inflamed surface. Death often takes place from marasmus within a few months, or from the effects of some secondary infection, as with a pneumococcus, during the first or second year. Children who survive the teething period have comparatively good health until puberty throws a fresh strain upon them. They may suffer from chronic osteitis causing "nodes"; joint affections, often mistaken for tuberculous disease; epiphyseal changes and inflammations of the spongy bones of the head, leading to "saddle nose." Many syphilitic children become deaf about puberty owing to disease of the internal ear: they show peculiar changes of the permanent teeth, more especially of the upper lateral incisors, for the teeth are ill-developed, deficient in enamel, conical in shape, and often crescentic in edge—Hutchinson's teeth—and they suffer from interstitial keratitis. These three conditions of deafness, malformed teeth, and inflammation of the eyes were used by Sir Jonathan Hutchinson as a tripod to support a diagnosis of congenital syphilis at a time when as yet there was no scientific method of diagnosing the disease. About the period of puberty, too, the knee-joints may be the seat of chronic painless synovial effusion, a condition described by Mr. H. H. Clutton.

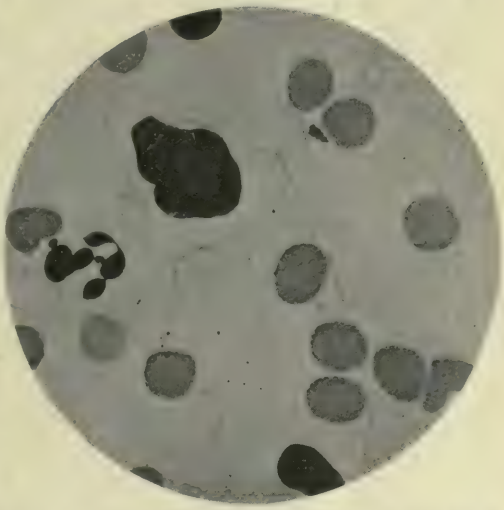


FIG. 7.—*Spirochæta pallida* in the scraping from the cut surface of a chancre of the penis, 6½ weeks after infection (Hoffmann).

The signs of congenital syphilis generally cease on the completion of the changes occurring at puberty, though chronic inflammations of the hyaline articular cartilages of the joints sometimes occur, leading to chondro-arthritis, described by Von Gies and afterwards by Virchow. Congenitally syphilitic patients often appear to be healthy, and they may show very few "stigmata" of disease. Any attack of illness, however, proves them to be deficient in vitality, and they rarely attain longevity. It happens occasionally that persons from whom no history of congenital syphilis is obtainable and who have no stigmata of the disease develop unmistakable signs of inherited syphilis comparatively late in life, and such cases are known as "syphilis hereditaria tarda." Gummatous orchitis, chronic superficial glossitis, and gummatous inflammation of the long bones, occurring as late as thirty in

persons who are undoubtedly free from acquired syphilis, are the more usual manifestations of late hereditary syphilis.

There is no proof at present that syphilis can be transmitted to a third generation, although the offspring of parents who are affected congenitally show a diminished power of resistance to disease.

**Diagnosis.**—The diagnosis of syphilis, which used to rest wholly upon clinical evidence, is now capable of scientific proof in a large number of cases, although there must always remain a certain proportion in which diagnosis is doubtful, partly from the impossibility of a proper examination, partly from carelessness on the part of the patient, and partly from the fact that the initial lesion and the secondary signs have been so slight as to lead to the disease being entirely overlooked.

The clinical evidence of syphilis depends upon the length of time the initial lesion appeared after infection, upon its characters, and upon its sequelæ. All are fallacious. It is not always easy to obtain truthful statements from the patient as to the date of infection ; simultaneous infection with Ducrey's bacillus, producing soft sores, may mask the appearance of the hard sore, or the position of the sore may lead to its being overlooked—as when it occurs on the os uteri or in the male urethra—or to its being misinterpreted, as when it appears on the face or fingers. The characters of the sore, too, may differ greatly from those usually described. Induration may be absent, or the sore may run an unexpectedly simple course. In like manner the sequelæ may pass unnoticed, for mucous patches may be absent and the skin eruption may be inconspicuous. Many cases of syphilitic infection therefore pass unnoticed, and the patient says in all sincerity that he has never suffered from the disease, although there is undoubted evidence of long-standing spirochæte infection.

It is most important for the cure of the patient that the disease should be recognised as soon after infection as possible. Every doubtful case should be submitted to scientific examination, and under no condition should the patient be allowed to wait until secondary symptoms have appeared before treatment is commenced. The finding of *spirochæta pallida* by a competent observer is proof positive of the disease, and this is fortunately not a difficult matter for those who are even moderately versed in modern bacteriological methods. The spirochætes can be obtained easily from primary and secondary syphilitic lesions, although in dealing with mucous patches from the mouth it should be remembered tha the *spirochæta dentium*—part of the normal fauna of the mouth in those who have decayed teeth—may easily be mistaken for the *spirochæta pallida*. The lesion is cleansed with saline solution until all débris are removed and clear fluid can be squeezed out. Some of this fluid is removed with a capillary pipette and is transferred to a thin slide, where it is examined either in a solution of Chinese ink or by the method of dark ground illumination with the ultramicroscope, using a No. 6 Zeiss ocular and a one-sixth dry objective. The spirochæte then appears as a shining spiral body about twice the length of a red blood corpuscle. It is remarkable because it retains its spiral form during rest as well as when it is moving, whilst most of the other spirochætes lose their spirals whilst resting. The isolated spirochætes can thus be seen unstained, but they can also be stained and demonstrated in the tissues.

Wassermann's reaction, introduced in 1906, and Noguchi's cutaneous luetin reaction, introduced in 1913, are both useful in connection with the diagnosis and treatment of syphilis. Wassermann's test can only be applied where there is an efficient pathological laboratory with trained assistants.

Like Widal's test in enteric, it depends upon the presence or absence of haemolysis under certain known conditions, and, although a similar result is obtained with other diseases, it is sufficiently satisfactory to raise a strong presumption of spirochæte infection when it is found to be positive in an Englishman who has not been the subject of sleeping sickness, leprosy, malaria, or framboesia, and who is not suffering from scarlet fever. The test is sometimes positive in five to six weeks after infection, and it is usually positive in nine to ten weeks after inoculation. It is the rule during the secondary period, and is very frequent during the existence of tertiary lesions. In parasyphilitic or parenchymatous syphilitic lesions the cerebro-spinal fluid as well as the blood must be submitted to Wassermann's test. The test is usually positive in congenital syphilis, but during the latent periods of syphilis, whether acquired or congenital, it is less constant.

Noguchi's test is analogous to Von Pirquet's test for tuberculosis. The test emulsion is called luetin, and is an extract of the cultivated spirochæte killed by heat and carbolised with a 0·5 per cent. of phenol. A drop of the luetin is injected into the skin of the arm and a drop of a control into a corresponding point in the other arm. In syphilitic patients a papule surrounded by a bluish-red halo appears in six to twenty-four hours or later. The papule develops a central area of suppuration and eventually ruptures, a sero-purulent fluid escapes, the surrounding epidermis becomes denuded, and a hypertrophic condition of the skin may remain for some months. It is too soon as yet to make any definite statement as to the value of Noguchi's test for purposes of diagnosis.

**Prognosis.**—The prognosis of syphilis has improved greatly since the cause has been known, and it has been possible to obtain scientific evidence of the existence of the disease instead of trusting to clinical facts and a time limit, as was formerly necessary. There is no question that many cases of syphilis are cured by natural processes, but the disease has such long latent periods and ends so disastrously for the individual as general paralysis, tabes, aneurysm, and cancer of the tongue, and for the race as congenital syphilis, that no patient should be allowed to go untreated. Salvarsan or neo-salvarsan injections should be given as soon as the disease is recognised, without waiting for Wassermann's test or the appearance of secondary symptoms, and should be followed at once by a course of mercury. The patient must be warned when he is first seen that this course of treatment must be honestly carried out for at least two years, and it may be longer: until the Wassermann test is negative on more than one occasion, after "a provocative dose" of salvarsan and when no mercury has been taken for three weeks. It is only under these conditions that a patient should be given permission to marry, and even then he must be told that he is cured only so far as is known in the present state of medical science.

**Treatment.**—The treatment of syphilis is directed to two objects—the cure of the disease and the lessening of its after-effects should it prove to be incurable. There is evidence to show that syphilis is at first localised to the point of infection and only becomes slowly diffused throughout the body. The preventive treatment may therefore sometimes be applied usefully where there has been an obvious exposure to syphilis, as in the case of a midwife delivering a woman with active syphilis, or a surgeon who inoculates himself whilst circumcising a patient with a primary sore. The wound or abrasion should be made to bleed freely, it should be well washed with soap and water, dried, and a mercurial ointment should be rubbed in for at least five minutes. Such treatment has been experimentally successful within twelve hours of

inoculation when the controls showed that the virus was active. Usually, however, it is impossible to obtain any proof that the disease has been contracted until the spirochæte can be demonstrated or the primary sore makes its appearance. In these cases a dose of salvarsan (0·6 gramme) or neo-salvarsan (0·9 gramme) should be given intravenously, and a mercurial course should be begun at once. The course of mercury is best given once a week by intramuscular injection, ½ grain of calomel in an emulsion for the first two injections and 1 grain of metallic mercury also as an emulsion for the succeeding eight injections. The emulsion is made according to the late Colonel Lambkin's formula : calomel grammes 5 (or metallic mercury grammes 10), creasote and camphoric acid āā cc. 20 ; palmitin basis to cc. 100. Ten minims of this cream contain ½ grain of calomel or 1 grain of mercury. Its melting point is 98·6° F. Three injections of salvarsan should be made at intervals of a fortnight during the twelve weeks during which the course lasts. By using this course of treatment Lieutenant-Colonel Gibbard and Major Harrison, R.A.M.C., were able to report to the International Medical Congress held in London in August, 1913, that in the British Army " the use of salvarsan had saved 70,000 to 80,000 days of hospital treatment and had effected an economy equal to the cost of keeping a battalion in hospital for three months."

Salvarsan is a synthetic organic compound of arsenic introduced by Professor Ehrlich in 1909 under the name " 606," which implied that it was the 606th preparation synthetised from the amido group of phenyl-arsenious acid. Further investigations led him to prepare a condensation product of salvarsan with formaldehyde sulphoxalate of sodium (neo-salvarsan), which is soluble in water, can be given in smaller bulk and with a simpler *technique* than salvarsan, although a larger dose is needed. In giving either drug it should be remembered that large doses of arsenic are being administered, that some persons are unduly affected by it, and that disastrous results have followed where it has been administered carelessly or with insufficient knowledge. The administration in every case should be treated as a surgical operation ; the patient should be purged over night, his urine should be tested to determine whether his kidneys are performing their functions satisfactorily ; the patient should be kept in bed for some hours before and after the injection, and food should be temporarily withheld. The earlier the treatment by salvarsan and mercury is begun the better are the results, and it must be continued systematically until the Wassermann test remains negative when it is done by a competent bacteriologist. This treatment can only be carried out in its entirety when a patient is under authority or when he is sufficiently educated to understand the magnitude of the risk he is running by a less efficient course. Mercury may be given otherwise than by intramuscular injections, but salvarsan or neo-salvarsan intravenously must be insisted upon. Mercury can also be given by inunction in the form of blue ointment to the amount of 1 drachm or 1½ drachms rubbed into a clean and dry skin in courses lasting a month or six weeks, as occasion requires. The least satisfactory method is the usual one of giving mercury by the mouth in the form of a pill, powder, or draught. When this has to be done, however, the mercury is administered either in the form of pulv. hyd. cum creta to the amount of 3 grains three times daily for an adult, or as the nauseous liquor hydrargyri perchloridi 1 drachm three times a day. Both preparations may cause indigestion and diarrhœa, and in persons who suffer from carious teeth or pyorrhœa alveolaris they are apt to produce salivation. In the later stages of syphilis, where the spirochætes or their toxins have led to the production of inflammatory tissue, the use of potassium iodide in

combination with mercury given by the mouth is distinctly advantageous: but potassium iodide is in no sense curative of syphilis; it merely assists the tissues to reabsorb the inflammatory cells, and thus leaves the spirochætes and their toxins more readily accessible to mercury and salvarsan, the true anti-syphilitic remedies. The modern treatment of syphilis, therefore, may be summed up in a very few words:—early diagnosis by recognition of the spirochætes; early administration of salvarsan or neo-salvarsan before or whilst the infection is still localised; always a thorough course of mercury.

## Soft Chancre.

**Definition.**—Soft chancre, ulcus molle, and chancroid are names given to an ulceration of the generative organs which constitutes the third form of venereal disease usually occurring in this country. It is an infectious disorder transmitted by impure coitus and associated with the presence of large numbers of gram-positive cocci, fine clubbed bacilli, and Ducrey's gram-negative bacilli. Soft chancre is distinct from syphilis and from gonorrhœa. It can, however, co-exist with either or both of these diseases, or it may be acquired independently. Broadly it is a filth disease and is most frequent where there is a low standard of personal cleanliness.

**History.**—Its history appears to be more difficult to unravel than that of either syphilis or gonorrhœa. Buboes, acute inflammatory phimosis, and phagedæna of the generative organs certainly existed in classical times when as yet there was no syphilis. The appearance of syphilis in Europe and the co-existence of syphilis and soft sores soon masked their separate identity, and they were looked upon as one disease until Bassereau in 1852 and Clerc in 1854 taught clinically that "neither in age, sex, constitution, nor tissue really lies the cause of the difference. It is due to a difference in the specific disease or virus." This was confirmed in England in 1862 by Marston, then an assistant surgeon in the Royal Artillery. In 1889 Ducrey announced his discovery of a bacillus in pus derived from buboes associated with soft sores.

**Bacteriology.**—The bacillus found in chancroidal pus by Ducrey and in the tissues by Unna is a short thick rod with rounded ends. It occurs singly, but its more usual arrangement is in short or long chains aggregated into masses. It stains readily with any basic aniline dye, and is decolourised by Gram's method. It is found in the depths of the ulcer or in its wall rather than in the secretion.

**Diagnosis.**—Soft chancres are characterised by many points which enable them to be distinguished clinically from syphilis. Their incubation period is shorter; they are auto-inoculable: that is to say, they can be reproduced by direct infection on the skin of the patient himself, and they are therefore usually multiple; they occur as readily on squamous epithelium as on columnar epithelium; the lymphatics are quickly involved, and suppurating buboes in the groin are of frequent occurrence. They destroy the tissues more or less widely and deeply, and in consequence they leave scars. They are curable, and, except for the after-effects of the cicatrices, cause no further trouble.

It has already been pointed out that as a result of the modern treatment of wounds the syphilitic point of inoculation is less frequently associated with the inflammatory induration which earned for it the name of "a hard sore." The classification of venereal sores into "hard and soft," therefore, is of less importance, and is apt to be more misleading, now than it ever was. The diagnosis depends wholly upon the presence or

absence of the *spirochæta pallida*. When this organism is present the patient has syphilis, and he may in addition be suffering from chancroids. The absence of the spirochæte would show that the sore was not syphilitic, but so many fallacies attend the examination in the earlier stages that it is better to keep the patient under close observation both clinically and bacteriologically until a correct diagnosis has been made. Chancroids may run their course and heal before the syphilitic incubation period is ended. Their presence, on the other hand, may mask the earlier stages of the syphilitic infection.

**Course.**—The incubation period is rarely more than twenty-four hours, longer if the infection has to make its way through uninjured stratified epithelium, shorter if there is an abrasion or a thin mucous membrane to penetrate. The initial manifestation is a small yellow spot surrounded by a zone of acute inflammation. The central spot soon ulcerates, and if it is single becomes a circular or oval ulcer with a sharply-cut and overhanging edge. When the ulcers are multiple they may fuse together to form an irregular ulcerated tract with crenate edges. They are covered with an abundant secretion of a thin and brown pus which is often blood-stained. The base of the ulcer after the discharge has been washed away is seen to be covered with a yellow pellicle which is interrupted by small red points. The base and the surrounding zone of inflamed tissue are œdematous, and this œdema leads to a thickening from which the ulcer obtained its name of soft sore.

Chancroids are found in the male upon the glans penis, in the sulcus behind it, on each side of the prepuce, on the meatus of the urethra, and inside the urethra itself. They are also found upon the scrotum, thighs, and pubes as a result of auto-inoculation. In women they are found round the vulva, on the labia majora and minora, and on the os uteri. They occur in the perinæum, at the anus, on the thighs, and on the pubes also as a result of auto-inoculation. They produce much œdematous swelling when they are situated in the loose connective tissue of the labia, and cause very foul and extensive ulceration in the lowest class of prostitutes. Both in men and women the inguinal glands are quickly inflamed. They often suppurate, and a bubo is produced. Less frequently the ulceration spreads rapidly, leads to gangrene, and is called phagedæna. In men with a tight foreskin the swelling caused by the chancroidal inflammation leads to an acute phimosis.

**Prognosis.**—The prognosis is good if the patient is in sound health and comes under treatment early. The scar of the healed ulcer will necessarily be permanent; and if the bubo has suppurated and has been incised, there will be a horizontal scar parallel with and situated just below Poupart's ligament. If the inflammation has run a phagedænic course there will be a permanent loss of tissue which makes the affected part look as if it had been bitten away. The scar, however, is supple, and there is no interference with the function of the part, except when the ulcer has been at the orifice of the urethra or within the first half-inch of the penile urethra the lumen is diminished, and a stricture results. This stricture is usually resilient in type, and is best treated by internal urethrotomy.

**Treatment.**—Chancroids are to all intents and purposes poisoned wounds, and they should be treated on ordinary surgical lines. Buboes and excessive inflammation follow upon prolonged stimulation, and the patient should therefore be kept at rest. The ulcerated surface should be thoroughly examined, and the discharge should be removed by prolonged baths, followed by compresses of iodine (℥i. ad O i.) or of peroxide of hydrogen (5 vols.). Mr. C. H. Mills has recently had good results by telling the patient to rub sublimed sulphur into the sore frequently and thoroughly. In men, if the prepuce cannot

be easily retracted and replaced, or if there is phimosis, an anæsthetic should be given, and the prepuce should be incised either in the median line dorsally or by two lateral incisions. A formal circumcision should not be performed, and the inflamed tissues should not be sutured.

In women a speculum should be passed after the vagina has been irrigated with an iodine douche, and the ulcerated surface should be touched with a 1 in 20 solution of carbolic acid daily.

More active measures must be taken if there is phagedæna. The best plan is to put the patient under a general anæsthetic, scrape and cut away the dead tissue until a clean surface is obtained, and then apply pure carbolic acid to the whole area. The tissues will turn grey, but the carbolic acid does not penetrate to any great depth. The whole surface is irrigated with a warm saline solution after the acid has been allowed to act for five minutes, and in a day or two when the superficial slough has come away, the part having in the meantime been treated by the application of iodine or Sanitas compresses, a healthy granulating surface is left.

The bubo may be a mere enlargement of the inguinal glands in one or both groins; it may be an acute abscess; or it may be a chronic enlargement of masses of glands which show no tendency to suppurate. Rest, an evaporating lotion, or painting with ichthyol are sufficient treatment for simple painful enlargement of the glands. A suppurating bubo may be aspirated and afterwards injected with a 1 in 20 solution of tincture of iodine, as recommended by Col. L. W. Harrison, or it may be opened by a sufficiently large vertical incision. A drainage tube may be introduced into the abscess, but it should not be packed with gauze. Hot fomentations should be ordered until the wound heals by granulation. The large masses of glands should be removed by dissection if they show no tendency to subside.

## Herpes Progenitalis.

Herpes occurs in men on the prepuce and at the point where the preputial mucous membrane is reflected on to the glans; in women the eruption is situated on the labia majora and minora, round the urethral orifice, and on the clitoris. The appearance of the vesicles is heralded by local heat and itching which draws attention to the part. The vesicles may be single, but are more often multiple and grouped in the course of a nerve distribution. Each vesicle is surrounded at first by a congested area, but they soon coalesce to form a slight superficial erosion, which may ulcerate if it is irritated in persons of uncleanly habit. In many cases the herpetic character is easily recognised, but a bacteriological examination should be made before a positive diagnosis is given, lest the erosion should be associated with a spirochætal infection or with Ducrey's bacillus.

*Treatment.*—The treatment consists in keeping the parts clean and dry with a dusting powder of starch and zinc oxide. All sources of irritation must be removed, and attention should be given to the general health of the patient.

## Gonococcal Infections.

The gonococcus is the most important member of that group of cocci which includes the *meningococcus* and *micrococcus catarrhalis*, all of which fail to stain by Gram's method.

It is responsible for a muco-purulent inflammatory condition of various mucosæ, most commonly those of the urethra in the male, urethra, cervix uteri in the female, and the conjunctivæ of both sexes, especially in new-

born children. In rare cases the rectal mucosa may be the site of infection. An epidemic form of gonococcal vulvo-vaginitis occurs in children and is frequently seen in hospitals. Genital infection occurs during coitus ; other sites are infected by means of fingers, sponges, or towels.

No preliminary lesion of the mucosa is necessary for infection to occur, as the cocci penetrate into the submucous tissues by passing between the epithelial cells ; they are also found in the cells : an acute œdematous catarrh is set up with desquamation of the epithelial cells and exudation of the leucocytes from the vessels into the urethra ; this mixed with mucus constitutes the discharge.

**Bacteriology.**—The gonococci are found in the acute stages lying mostly free in the pus, but later, both in the leucocytes and those cells derived from the epithelium, as diplococci, reniform in shape, staining by the ordinary aniline dyes, but not by Gram's method. In order to grow them inoculations of the purulent material must be made into blood agar or ascitic agar, in which growth will take place after eighteen to forty-eight hours. They die very readily on artificial media. No other animal except man is susceptible to infection, so that in order to fulfil Koch's axiom inoculations must be made into the male urethra.

The condition resulting from acute infection may resolve completely or, combined with secondary infection with staphylococci or streptococci, pass on to a chronic stage. Under these circumstances subepithelial fibrosis takes place and a stricture of the affected tube is liable to result. Fibrosis is the common terminal result of infection of any organ by the gonococcus, but localised suppuration may take place.

Either the acute or chronic condition may involve the neighbouring structures—*e.g.*, the genital or urinary tracts and the peritoneum in the female —the micro-organism spreading by continuity or *viâ* the lymphatics.

In both stages also blood infection may take place, with the production of such lesions as arthritis, fibrositis, iritis, panophthalmitis, endocarditis, pericarditis, pleuritis, bacteriæmia, or even pyæmia.

The diagnosis of gonococcal infections should always be made by film and culture preparations. All forms of urethritis are not necessarily due to this micro-organism, although the majority are. Aspirations of infected joints often meet with negative bacteriological evidence. Yet such should not be omitted for that reason. Similarly blood cultivations should be made in disseminated conditions, and in obscure cases the complement fixation test should be tried.

**Treatment.**—The treatment of gonococcal infections is the same as for other bacterial conditions. Attention should first be paid to the local focus of primary inoculation ; local antiseptics in mild form should be applied (see *Gonorrhœa*, Section XXVIII.). Prophylactic measures require to be taken to prevent local and general dissemination. Even when the latter have occurred, strict attention should be paid to the local focus.

*Vaccine therapy* plays an important part in the treatment of generalised dissemination and for the most part is efficacious, it being more valuable for this than any other form of gonococcal infection. There is but little evidence as to its value in dealing with localised infections. In generalised diseases, which show a marked tendency to recurrence so long as there is a primary focus, repeated inoculations of autogenous agents tend to prevent such. If an autogenous agent cannot be obtained, a mixed vaccine of several strains of gonococci is often valuable. Sensitised and detoxicated vaccines have been more recently utilised with success.

Dosage should be carefully studied, as vaccines prepared from this coccus are markedly toxic, and only small doses should be given at the initial injection.

In chronic infections an attempt should be made to demonstrate that the effects are due to the gonococcus, and not to one of the secondary bacteria which commonly complicate the primary infection.

## Tumours and Cysts.

When the term *tumour* is used in its more limited sense, it excludes the swellings caused by inflammation, such as syphilis and tubercle, and mere hypertrophy of a normal tissue or organ. *Cysts*, under which very various pathological formations are included, will be considered separately.

The elements of which a tumour is composed resemble superficially the normal tissues and cell elements of the body, either in their mature or immature state. Thus, the tissue elements of a tumour resemble bone, cartilage, fat, or embryonic mesoblast, whilst the cell elements are like epithelium or endothelium. The arrangement, however, is unlike any normal structure; besides, the tissue of a tumour serves no useful purpose, but the reverse.

**Development.**—Tumours arise by the multiplication of pre-existing cells, which divide by regular or irregular karyokinesis, and are supplied with new blood-vessels by a process of budding out from previously existing ones. Tumours appear to retain throughout their growth the type of cell from which they start; epithelial tumours retain the special type of epithelium —columnar or squamous—from which they spring; connective tissue tumours, as they continue to grow, retain their original composition of fat or connective tissue cells, but in any form of connective tissue there may originate a growth, *sarcoma*, composed of cells like the mesoblast of the embryo.

All tumours set up inflammatory changes, followed by the development of fibrous tissue. This may be limited to the boundary zone between the tumour and the healthy tissue around, so that a capsule is formed. In the case of epithelial tumours the cells seem to act as irritants, like foreign bodies, and set up inflammatory changes within the tumour itself. There is found amongst the epithelial-cell elements a variable amount of tissue resembling connective tissue. It is generally held that this is formed from connective tissue cells, but by some that a change in epithelial cells gives rise to this form of fibrous tissue. Along with this new formation of fibrous tissue there is a new formation of irregularly distributed blood-vessels. The newly-formed blood-vessels are most plentiful in the growing zone; in the substance of a tumour, and particularly in a degenerating one, blood-vessels tend to disappear.

The proliferation of cells in tumours goes on by mitosis, which may be similar to the typical somatic mitosis, or be "heterotypical," resembling that occurring in reproductive cells.

**Classification.**—The origin of tumours is obscure and in most instances quite unknown, and it is impossible, therefore, to make an efficient classification.

An attempt has been made to do so by utilising as a basis the embryological layers from which the tumours have grown. Thus, a growth is described as an epithelial, a connective tissue, or a teratoid tumour, according as it originates from the epiblastic or hypoblastic layers, from the mesoblast, or contains elements of all three layers (teratoma) respectively.

A further subdivision may be made from the histological appearances; thus a tumour is described as a lipoma or chondroma if its structure resembles that of fat or cartilage.

Tumours are also classified into innocent and malignant, according to their clinical course. An innocent tumour grows by merely displacing normal tissue, whilst a malignant one actively invades, destroys, and disseminates.

**On the causation of tumours.**—1. *Local irritation, generally long-continued.*—This factor is especially important in bringing on the growth of squamous-celled carcinoma. The tongue or lip is affected by the irritation of smoking, a sharp tooth, or a syphilitic inflammation; in India, the buccal pouches, by the chewing of betel nut mixed with tobacco. Epithelioma of the penis is frequent in hot climates among the uncircumcised as compared with its great rarity in the circumcised. In Kashmir cancer is frequently caused by carrying glowing charcoal in baskets close to the skin. Irritation of the skin by chronic ulceration, the contracted scar which follows burns, sunburn, the eczema set up by the administration of arsenic, the working with soot in the case of chimney-sweeps and gardeners, and the irritation of discharges from sinuses dependent on dead bone, retained bullets, etc., may all be antecedents of cancers.

Cancer arises in the mucous membrane of the biliary system, especially in connexion with the irritation of calculi. On the other hand, cancer occurs in some common positions without evidence of previous irritation. Thus in the case of cancer of the stomach, which causes the death in males of about 20 per cent., and in females of about 13 per cent., of all those dying of cancer in this country, it is the exception for symptoms of gastritis and ulceration to precede the cancer. So also in the case of the breast, evidence of previous inflammation, except in connexion with the nipple, is rather the exception than the rule. In the frequent cancers of the colon and rectum there is no evidence usually of any previous inflammation.

The irritating substance is entirely conjectural. In the case of chimney-sweep's cancer of the skin, particularly of the scrotum, the irritant is clearly in the soot, and the diminution in frequency is apparently the result of greater cleanliness and the use of better appliances which obviate the necessity of climbing up the interior of chimneys. The irritant resides in the soot derived from coal, as the disease was noted in the eighteenth century when the use of coal became general in this country, whilst in France, the leading country in surgery, but where wood was chiefly consumed, the disease was hardly noticed. It is at the same time not seen among miners begrimed with coal-dust. The irritant must therefore be produced in the combustion of coal. With this agrees the fact that epithelioma has been caused on the hands of gardeners using soot, of gas-tar workers, and of those engaged in the manufacture of carbolic acid. It may be some product of combustion which is the irritant in the case of smoked tobacco, although epithelioma has arisen on the inside of the cheek from chewing it. Cases, however, from snuff-taking, formerly so prevalent a custom, are not mentioned. But as in smoking tobacco, so also among chimney-sweeps, there appears to be some peculiar tendency in the individual; chimney-sweeps of some families, father, son and grandson, have suffered, whilst other families similarly exposed remained free.

2. *The influence of blood-clot.*—Following injuries, especially to the head and long bones, sarcoma sometimes starts and rapidly proves fatal, as if the cause of the cancer found a favourable nidus in the blood-clot. But again there must be some individual peculiarity, for these tumours have been noted

after trivial blows on the head or shin, such as are of every-day occurrence. However, 7 to 14 per cent. of all tumours are said to follow injury.

3. *By cell-inoculation.*—There is this positive evidence as to the possibility of the transference of cancer, that it can be inoculated from one mouse to another of the same breed through a long series of mice. Warts, in the case of man, and similar papillomata on the genitals of dogs, can be inoculated, and in the latter case have been transferred by experiment to the peritoneum. A man and his wife have died of cancer within a short time of one another (cancer à deux), *e.g.*, the woman of cancer of the cervix, and the man of the external genitals. In other instances the cancers have not corresponded; a woman with a fungating tumour of the breast has been nursed by a daughter who has afterwards died of uterine cancer. A second epithelioma has been noticed to arise upon a surface which has come in contact with the primary growth, *e.g.*, upon the cheek opposite an epithelioma of the tongue. But the possibility of direct extension must be considered. Recurrence in the scar has been attributed to cell inoculation at the operation. But in the case of a mammary or other cancer the skin outside the area of excision may have been already invaded, or a deep-seated abdominal cancer when it recurs may spread to the surface.

4. *Endemic origin.*—Cancer has been stated to be prevalent in some districts, especially along valleys and river courses, *e.g.*, the valley of the Thames.

5. *Causation by infection.*—The attempts to transfer malignant disease from man to animals, also the tumours, including cancers, which are prevalent among animals, to other animals, except in mice, have ended in the inoculated material being more or less gradually absorbed by inflammation and phagocytosis set up in the surrounding parts. Experiments as to organisms have been negative. Errors have been made:—(*a*) Objects existing in tumours have been stained and called organisms, when really these have been produced by irregular mitosis and cell-degeneration. (*b*) Organisms have been cultivated from tumours, but they set up nothing except inflammation when inoculated into animals. The whole tumour has been regarded as a parasite; the cancer cells themselves have been deemed protozoa, and likened to psorosperms, such as set up the parasitic disease of the liver in domesticated rabbits, although on examination of such livers it will be seen that this process is an inflammatory one.

6. *By uncontrolled cell-proliferation.*—The development in an atypical manner of cell elements, which in themselves closely resemble normal cells, has suggested the theory that some influence, nervous or other, normally controlling and directing cells, is taken off, so that the cells continuously proliferate. A cell may be considered to be under the restraining or tonic influence of surrounding cells and tissues, and with the removal of this control the cell grows and divides abnormally. Injury or inflammation, by detaching cells from their normal control, may thus be the antecedents of tumour formation. In support also of this theory, changes in connexion with old age are mentioned. The connective tissue of the skin and subcutaneous tissues atrophies and becomes looser, whilst epithelial cells retain activity, or even become more active, causing new formation of hair about the ears, eyebrows, and nasal orifices. However, this theory does not at present carry us beyond the fact of the continuous atypical development. Nerve paralysis does not lead to tumour development. But some cases of rodent ulcer and slow-going epithelioma appear to develop in connexion with the terminal ends of a nerve and to remain for some time confined to the distribution of the nerve. This is especially to be noted on the face, in connexion with the terminal branches

of the fifth nerve (Cheatle). A partial explanation of this may be that the growth finds an easy way along lymphatics and veins, corresponding in distribution to the nerves.

7. *Developmental tendencies.*—All ill-developed tissues are especially prone to originate tumours, sometimes before, often long after, puberty. An ill-formed breast with a retracted nipple often becomes the seat of malignant disease. Warts and moles on the skin give rise to growths by proliferation of the cells composing them. Congenital remnants of fœtal structures in the kidney and ovary become the seat of malignant disease. Some tumours, indeed, may be regarded as local malformations. The existence of embryonic tissue supports the theory, called Cohnheim's, that tumours arise in embryonic *restes*.

8. *Inherited or acquired tendencies.*—Hereditary tendencies transmitted direct from father or mother to offspring explain the fact that sometimes several members of a family suffer from tumours; more often there is a vague account of one more or less distant relation having been affected. But even then the tumours so connected may not be of the same kind, and hence the influence of heredity must be obscure. Tumours tend to develop at various ages, sometimes in connexion with the active growth of early life, more often during the slow degeneration attending advancing age. They appear to arise sometimes in connexion with depressing influences, as grief, anxiety or mental strain, or from physical exhaustion.

**Clinical course.**—Clinically, tumours are spoken of as benign or malignant. They are liable to secondary changes, also to recurrence and dissemination.

*Benign tumours*, as a rule, grow slowly, and resemble the fully-formed tissues of the body, usually those amongst which they grow. They are generally encapsuled, circumscribed, and freely movable, merely *displacing* the tissues around, not infiltrating them. They do not involve the lymphatic glands, nor become disseminated in distant organs; neither do they recur if completely removed. They may, however, attain a large size and destroy life by pressing upon a vital organ, or in other ways interfering with the natural functions.

*Malignant tumours*, on the other hand, grow rapidly, do not resemble the fully-formed tissues in structure, and differ markedly in appearance from the tissues in which they grow. They are generally non-encapsuled, and *infiltrate* and replace the surrounding parts, whether muscle, fat, or bone, and in consequence become more or less fixed. They frequently involve the lymphatic glands, and become disseminated through the body by means either of the lymph- or blood-stream. They recur, after removal, in the scar, in the corresponding lymphatic glands, or in internal organs, and sooner or later give rise to a general cachectic condition depending upon septic or other absorption and known as the *cancerous cachexia*.

*Secondary changes* are common in tumours, especially in those of more rapid growth. Thus a tumour may become inflamed, or may ulcerate, or undergo fatty, mucoid, colloid, pigmentary, or calcareous degeneration; or as the result of these changes, or of hæmorrhage into its substance, cysts, or, more rarely, circumscribed abscesses, may form in its interior; or the whole tumour may undergo atrophy or necrosis, and, in exceptional instances, slough away. At times a tumour, at first benign, may after a longer or shorter period become malignant; for instance, a papilloma may degenerate into an epithelioma.

*Recurrence and dissemination.*—Early local recurrence is the result of some of the tumour elements having escaped removal, and may take place in the scar, or in the tissues immediately around. Reproduction in the neigh-

bouring lymphatic glands is due to the tumour cells becoming arrested in the lymph sinuses; metastasis by dissemination in more distant tissues and organs is caused by the tumour cells being carried by the blood-stream (which they may enter either directly, or indirectly by the lymph channels) to these parts, where they become lodged, and form starting-points for metastatic or secondary growths. Secondary growths, whether in the glands, or elsewhere, resemble in structure the primary tumour. Late recurrence *in situ* some years after the removal of the primary growth indicates a recrudescence of the original cause of the growth; cells from a malignant growth can lie latent for long periods.

## (A.) Connective-tissue Tumours.

### *Innocent or Benign Connective-tissue Tumours.*

**Fibroma or fibrous tumour.**—*Development.*—Fibromata or fibrous tumours are composed of tissue resembling normal white fibrous tissue. They originate from a previously existing connective tissue, by division of cells and formation of fibrils, as in the development of the normal tissues, but without forming elastic fibres, except occasionally near blood-vessels. They generally develop from one centre; but a number of small tumours may become united into a common mass. The consistency of fibrous tumours is variable. Some, called *Desmoid tumours*, are hard and tough, grating on section; the fibres are arranged concentrically or in whorls, appearing as a glistening white tissue resembling tendon or aponeurosis. They are composed microscopically of coarse fibrils arranged concentrically or interlaced, between which lie, in parallel rows, cells with elongated nuclei, and only a few blood-vessels. Others are soft, more vascular, greyish-white on section, and composed of fine loosely-arranged-fibres, and numerous connective-tissue corpuscles, with large round or oval nuclei. Hence these tumours have been called *fibro-cellular tumours*. Serous fluid to a variable amount can be squeezed out from their cut surface. Owing to this, fibrous tumours may rapidly enlarge and again shrink as the serous fluid is reabsorbed. They may be encapsuled or be continuous with surrounding fibrous tissue without any definite line of demarcation.

*Clinical varieties.*—When growing in the skin or subcutaneous tissue they form circumscribed sessile or more or less pedunculated tumours, often multiple and scattered over the body, called *molluscum fibrosum*. They tend when pedunculated to ulcerate and bleed; when they do so they should be excised with the pedicle, otherwise they may be let alone.

*Pachydermatocele* is a diffuse fibroma, causing the skin to become rugose and hang in folds. It affects especially the scalp, but also the skin of the trunk and limbs. The growth ultimately tends to become sarcomatous, and should therefore be excised and the area covered by skin-grafts, if this is in any way practicable.

Soft fibromata grow from the peri-odontal membrane (*fibrous epulis*); from the nose and naso-pharynx, where they become dependent (*naso-pharyngeal polypus*), and large veins developing about the pedicle, tend to cause hæmorrhage. In the breast fibromata develop with a more or less concentric arrangement round the canaliculi and remains of the alveoli, without any sharp demarcation from the remaining connective tissue of the breast. When only a little of the glandular element is enclosed in the tumour, it may be called an *adeno-fibroma*; when this is considerable and in excess of the

fibrous tissue, *fibro-adenoma*. In some cases, at any rate, carcinoma supervenes. Their excision, including some of the surrounding breast tissue, is required; in cases of doubtful malignancy, the whole breast. In the uterus and adnexa fibromata develop more or less in combination with the unstriped muscle of the uterine wall, of the tube and round ligament, being called *myo-fibroma* or *fibro-myoma*, according as the fibrous tissue or the muscular fibres are in excess; or simply *fibroids*. When combined with dilated vessels, arteries or veins, they are known as *angio-fibroma;* less often the fibrous tissue surrounds dilated lymph-spaces (*fibro-lymphangioma*). A fibroma may develop singly within the sheath of a large nerve (*neuro-fibroma*), or may grow near the terminal end of a sensory nerve forming the painful *subcutaneous nodule*, or many fibromata may be found scattered on many nerves, especially the cauda equina.

Fig. 8.— Molluscum Fibrosum.

Occasionally fibromata grow from deep connective tissue, intermuscular or periosteal, or from the fibrous capsule or septa of organs. All the fibrous tissue of an organ may be involved by the tumour growth. In the ovary they may arise in the scar of a *corpus luteum*.

Such fibromata generally form smooth, painless, encapsuled homogeneous tumours, distinguished from gummata by the appearance of a cross-section, and from fibro-sarcomata by their slow growth and non-recurrence after being removed.

*Keloid* is a peculiar form of fibrous new growth in scars (see *Cicatrices*).

*Secondary changes.*—The connective tissue changes into fat, or undergoes myxomatous degeneration, with a tendency to form cysts into which blood may extravasate, or a fibroma may gradually calcify.

**Lipoma**.—*Development.*—Lipomata or fatty tumours develop from the connective-tissue cells which contain fat, and so are not found in places like the skin of the scrotum. The fat-cells of the tumours resemble the normal.

*Clinical varieties.—Common fatty tumours.*—The commonest type of fatty tumour grows from the subcutaneous tissue, and, like it, is divided into lobules separated by fine septa of connective tissue. It is closely attached to the under-surface of the skin, which is somewhat puckered or dimpled by the growth. From the deeper structures the tumour is separated by a fine fibrous-tissue capsule. It has only a small blood supply. These tumours develop in adults on the shoulders, back, and buttocks, where they have been attributed to irritation; the rubbing of clothes, braces, etc., certainly

appears to stimulate growth already started. They are soft, elastic, "semi-fluctuating," painless, generally single, the edge slips away under the pressure of the finger, the skin dimples when pinched up, and there is no escape of fluid on puncturing. These signs serve to distinguish them from a chronic abscess, cyst, or bursa. As they grow they become pendulous, and congested, and may then ulcerate. They are removed by making an elliptical incision so as to include the skin to which the tumour is most closely attached, for sloughing might take place if this were dissected up; the rest of the tumour easily shells out with little hæmorrhage, but care must be taken not to leave behind any lobule, or the tumour will grow again.

*Sub-serous lipomata.*—When growing from the sub-peritoneal fat, near the internal abdominal ring, a lipoma descends by gravity along the spermatic cord to the scrotum; if in the linea alba or elsewhere in the abdominal wall, it forms

FIG. 9.—Soft pedunculated fibroma of skin, or molluscum fibrosum. (A photograph kindly lent by Mr. G. P. Newbolt.)

a small tumour, movable beneath the skin, the pedicle of which passes back through a gap in the aponeurosis. Occasionally one is seen to the side of the sternum, protruding between the ribs. A retroperitoneal lipoma in the lumbar region may reach to a large size.

*Submucous lipomata* grow from the fat beneath the mucous membrane of the pharynx, larynx, stomach and intestines. They may protrude into the lumen and form polypi.

*Intraglandular lipomata.*—Lipomata have been found arising in the fat between the lobules of the breast and kidney.

*Diffuse lipomata* show no capsule or distinct lobulation, and are more vascular than the common circumscribed lipoma. They are a local hypertrophy of the subcutaneous fat with which the margins of the tumours insensibly blend. They are met with in stout people, especially in those addicted to alcohol, and form rolls of fat at the back of the neck, beneath the chin, masses in the abdominal wall or about the hips. When occurring on

a limb, a lipomatous form of elephantiasis ensues. Diffuse lipoma is at first to be treated on the same lines as obesity. Iodide of potassium or thyroid extract may be cautiously administered. The patient must abstain from alcohol, avoid fat-forming foods, and take more exercise. Only when markedly impeding the patient's movements should any portion be cut out, and in any case the excision is only partial.

*Nævo-lipomata.*—Fatty tumours occurring before puberty are of congenital origin, with more or less nævoid tissue connected with them; they sometimes grow in connexion with the meninges, and are met with in spina bifida, when they may protrude externally or lie within the spinal canal. They may form part of a teratoma.

*Lipomata on the hand and foot.*—Small lobulated masses of fat grow on the palmar aspect of the hand and fingers, more rarely on the dorsal aspect and on the foot. They are partly subcutaneous, partly under the fascia alongside the tendon sheaths and between the lumbrical muscles.

*Intermuscular and parosteal lipomata.*—A lipoma may grow between the muscles of a limb until it reaches such a size as to produce a condition of elephantiasis. The lipomata growing in connexion with the periosteum, when congenital, have contained tracts of striated muscle fibres.

*Perineural lipomata.*—A deep-seated lipoma may be found attached to a nerve sheath.

*Lipoma arborescens* is the term applied to tufts of fat replacing and enlarging the synovial fringes of joints.

*Secondary changes.*—A lipoma may undergo partial myxomatous degeneration, *myxo-lipoma*, or by increase of fibrous tissue become a *fibro-lipoma*; or ulceration and sloughing may supervene.

**Chondromata, or cartilaginous tumours,** grow practically always in connexion with bone (see *Diseases of Bone*). The tumours containing cartilage growing in soft parts are described under *Endothelioma*.

**Osteomata, or bony tumours,** see *Diseases of Bone*.

**Odontomata, or tumours of the teeth,** see *Diseases of Teeth*.

**Myxomata, or mucous tumours** consist of tissue resembling that of the umbilical cord, or the vitreous humour. They are composed of stellate cells with oval nuclei and delicate fibrils, which enclose spaces containing a mucinous fluid. But no tumour arises from normal myxomatous tissue, nor is a tumour wholly composed of it; myxomatous tumours arise by transformations from others, and such tumours are then called myxo-fibroma, myxo-lipoma, myxo-chondroma, myxo-sarcoma. From fibrous connective tissue they arise by a formation of mucinous fluid between the fibrils, many of which tend to disappear. A common instance is the mucous polypus of the nose. If from fat, the fat globules disappear, and the cells shrink and become stellate, while between the cells the mucinous fluid collects. In the case of a cartilaginous tumour, the hyalin ground substance changes into a mucinous jelly, whilst the cartilage cells become stellate. In a myxo-sarcoma there are in parts masses of cells rapidly dividing, in others a collection of mucin between the cells.

Myxomatous tissue is of soft gelatinous consistency, is pinkish or greyish-white on section, and a tenacious or glairy fluid oozes from it.

The myxomatous tumours have the characters of the original growth. Myxomatous tissue in particular tends to form cysts, into which, by rupture of vessels, blood is very likely to be extravasated.

**Hæmangiomata**, see *Diseases of Arteries*.

**Lymphangiomata**, see *Diseases of Lymphatics*.

**Lymphadenomata**, see *Diseases of Lymphatics*.

**Myomata.**—The *leio-myoma* is characterised by unstriped muscular fibres, and may occur occasionally in the wall of the intestines, ureter, prostate, and in the skin, arising either from the wall of the blood-vessels or from the erectores pili, but it is chiefly met with in connexion with the uterus and round ligament. It is composed of unstriped muscular fibres mixed with fibrous tissue in various proportions. Myomata develop from unstriped muscular fibres which form strands arranged concentrically in whorls, or in waving bands, having on section a greyish-red appearance, or when largely mixed with fibrous tissue a pinkish-white. It may be difficult to distinguish a myoma from a fibroma until after macerating in nitric acid or caustic potash, when the spindle-shaped muscle cells with their rod-like nuclei can be recognised. Sections show the fibres cut in all directions, longitudinally, obliquely, and transversely. In the last case the muscle-cell outlines appear as areas of various diameters, with a darkly-staining dot in the centre, the size varying according to the point at which the spindle cell and its rod-like nucleus is cut across. They are separated from their surroundings by a fibrous capsule except when the whole organ, *e.g.*, the uterus, is affected. They may undergo myxomatous degeneration forming cysts, may gradually become more and more fibrous, calcify, or partially change into fat. Finally they may metamorphose into sarcoma.

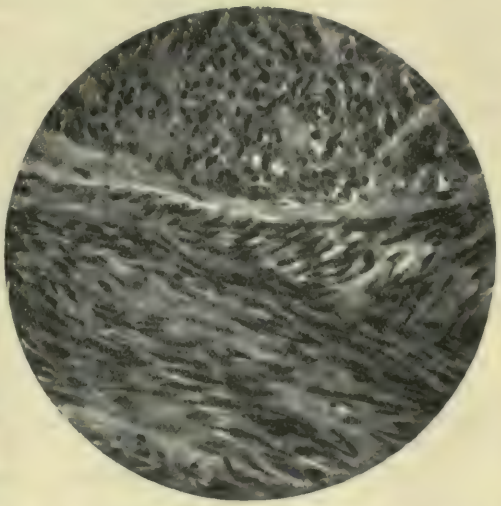


FIG. 10.—Myoma. Photograph of a section through a myoma. In the lower half the strands of unstriped muscle fibres are shown in longitudinal section, in the upper half cut transversely, and between are some fibres cut obliquely.

A myoma or fibro-myoma of the uterus may include epithelial elements, columnar cells and gland tubes from the fundus, squamous epithelium from the cervix, or tubular masses of cells connected with the Wolffian body. Hence the term *adeno-myoma*.

The *rhabdo-myoma* is composed largely of elongated spindle cells with transverse and also longitudinal striations. They are rare tumours which have been met with in the kidney, testis, uterus, vagina, bladder, and other places. In the kidney and testis the tumours are of a mixed complicated structure, *teratomata*, or rapidly growing sarcomata, *rhabdo-sarcomata*.

**Neuromata.**—A *true neuroma*, composed of nerve-fibres and ganglion cells, has been described, especially in connexion with the sympathetic. Mixed with fibrous tissue, it has been met with as a deep-seated tumour in the neck connected with a sympathetic ganglion. *Traumatic neuromata*, or bulbous nerve-ends, form on the cut ends of nerves, and are composed of newly-formed coiled, more or less incomplete, nerve-fibres mixed with fibrous tissue. *Fibromata* occur on nerves as mentioned above. *Neuroma plexiforme*, *neurofibromatosis*, or *Von Recklinghausen's disease*, is due to fibromatous thickening of the sheath

of the nerve and of the connective tissue, the endoneurium, immediately around the fibres, whilst the nerve-fibres themselves are increased in length so as to become very tortuous. Whether there is any new formation of nerve-fibres at all is doubtful, certainly not to any great extent. Chiefly medullated, but also non-medullated, nerves are affected. Clinically the tumours form in the skin of the scalp, also in the trunk and limbs, tending to produce fibrous folds and forming part of the condition described as pachydermatocele or elephantiasis.

**Gliomata.**—A *glioma* grows from the neuroglia forming the connecting framework of the central nervous system. In the brain, these tumours may be encapsuled, but also diffuse, showing no line of demarcation from the surrounding tissue. They develop in the spinal cord, especially around the central canal, being widely diffused. On section these tumours may be scarcely distinguishable from the surrounding nerve-tissue, or may appear more vascular, reddish, or actually show cysts containing blood-clot, or simply a glairy fluid from myxomatous degeneration.

Microscopically they are composed of delicate interlacing fibrillæ and cells, having darkly-staining round or slightly oval nuclei, very little protoplasm and delicate stellate processes. It is the neuroglia cells and not the nerve-cells which give rise to the tumour, and the more rapidly it grows the more cellular the tumour. In the latter case the connective tissue around the blood-vessels also is involved, and the tumour becomes a glio-sarcoma. The retina and optic nerve are common seats of glioma. An encapsuled glioma is a favourable kind of brain tumour for removal. The diffuse gliomatous degeneration of the spinal cord forming cysts is called *syringo-myelia*, and it occasions peculiar trophic disturbances in the bones and necrosis of fingers.

### *Malignant Connective-tissue Tumours.*

**Sarcomata.**—The tumours included under the term sarcoma form a varied group, having this in common, that the cells of which they are composed resemble those of embryonic or immature connective tissue derived from the mesoderm.

In these tumours the cell elements predominate, the intercellular substance being relatively unimportant. The cells, whilst retaining more or less the type of mesoblastic cells, undergo rapid division by regular or irregular mitosis, and rarely divide directly. The intercellular substance being small in amount, gives the section of the tumour a brain-like or medullary aspect, the so-called "medullary cancer"; if there is much intercellular fibrous substance, the tumours approach in appearance the fibromata, and were formerly known as "recurrent fibroids."

Sarcomata develop:—1. From the normal connective tissue in the skin and subcutaneous tissue, the intermuscular, periosteal or glandular connective tissue, from the walls of blood-vessels and lymphatics, from the sheaths of nerves, from the meninges, and from neuroglia.

2. In previously existing benign tumours, such as fibromata and myomata; also in inflammatory connective tissue, the result of injury with blood extravasation, or of syphilis.

3. In embryonic or young tissue. Some sarcomata are congenital, such as in the kidney, or they grow in malformations, and often appear in early life.

A sarcoma generally begins at one spot, but there are exceptions, such as in multiple sarcomata of the skin, where a number of tumours develop simultaneously without any sign of being metastases from a primary growth.

*Varieties of sarcomata :*

1. *Simple sarcomata* show mainly a variation in the shape of their cells, and the amount of intercellular substance. The blood-vessels have very thin walls, or are really mere blood-spaces bounded by the cells.

2. *Sarcomata showing peculiar pigmentary* and other changes in their cells and intercellular substance.

1. **Simple sarcomata.**—The cells are masses of granular protoplasm, without a distinct cell membrane, containing one or more nuclei. They are round, large or small, oval or spindle-shaped, the intercellular substance very scanty, semi-fluid, or consisting of fine fibrillæ irregularly arranged, as distinct from the parallel or concentric arrangement of the fibrous tissue in fibromata, nor are there definitely formed alveolar spaces, as seen in the carcinomata. The vessels are thin-walled channels formed by the adjacent cells, not definite vessels ramifying in a stroma. If growing slowly, they may be separated by a zone of inflammatory tissue forming apparently a capsule, yet this is often œdematous and ill-defined, and the growth tends to spread along connective-tissue planes. Extending by the veins, metastases develop especially in the lungs, also in the liver. The rapidly-growing kinds, the periosteal sarcomata in particular, also those in the breast, testicle, and tonsils, quickly cause a soft enlargement of the neighbouring lymphatic glands.

(*a*) *Round-celled sarcomata.*—These may be further subdivided according as they are composed of small or large round cells.

In connective tissue the round-celled sarcomata form soft, rapidly-growing tumours, composed simply of round cells and thin-walled blood-vessels. The cells have a spherical nucleus, around which is some cell protoplasm. It is therefore difficult to distinguish the tumour at its growing margin from the inflammation which the growth sets up. At the growing margin, bordering on muscle, masses of these cells, arranged in rows, are seen infiltrating the intermuscular connective tissue. But the nuclei of the cells of this growth do not stain so deeply as those of the inflammatory cells, are larger, and show karyokinesis.

These tumours are most common in the periosteum of bone, in the skin and subcutaneous tissue. In organs such as the breast and testicle they occur more rarely, tumours formerly termed sarcomata being now included under carcinomata. They grow rapidly, invading the neighbouring tissues. As they approach the skin, veins enlarge, the skin over them becomes livid, then gives way in the centre. Through this hole the tumour fungates without the skin being first infiltrated.

The fungation gives rise to septic infection and breaking down of the tumour, so that the patient's general health now begins to suffer, and cachexia sets in. Meanwhile the corresponding lymphatic glands undergo a soft enlargement; then pulmonary trouble appears. The patient presents, perhaps, signs of a pleural effusion, which on aspiration yields a serous fluid, mixed with blood. Then follow increasing respiratory difficulty with expectoration of prune-juice-like sputa, enlargement of the liver, also the appearance of rapidly-growing tumours in various parts of the skin, which in their turn fungate and bleed. Death soon follows.

*Diagnosis.*—It is difficult to distinguish a rapidly-growing sarcoma from inflammation started by an injury or due to syphilis. Such a sarcoma may occasion a rise of temperature to 102° F.; also, even apart from fungation, it is liable to septic infection from the skin or from a mucous surface, causing it to suppurate. When the diagnosis lies between subacute inflammation and new growth, if the Wassermann test is positive, anti-syphilitic measures, to

exclude a gumma, may be tried, but not for more than ten days when ineffectual. In the case of doubt an incision is made, and a portion of the material at once examined microscopically.

When near one of the large vessels a sarcoma may simulate an aneurysm, not only because it receives a communicated pulsation, but also because it shows to a certain degree expansile pulsation owing to its great vascularity. Nevertheless it does not shrink in the marked manner that an aneurysm does upon compressing the artery above. When, however, an aneurysm is partly filled by clot it will not empty, and then a consideration of the history, an X-ray examination and eventually a cautious exploration, form the only means of distinguishing the two.

*Large round-celled sarcomata.*—These are characterised by the large size of the

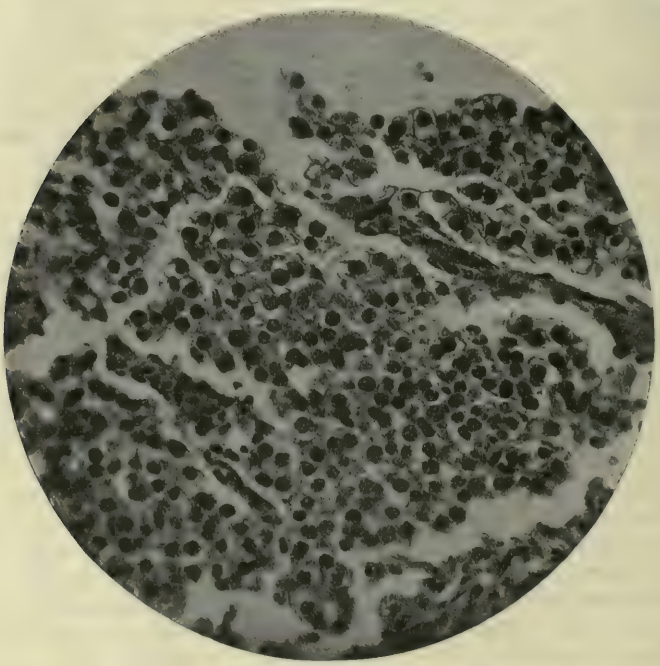


Fig. 11.—Photograph of a section through a large round-celled sarcoma.

cells, containing much protoplasm, with large oval vesicular nuclei. Many of the cells show karyokinesis, and contain two or four developing nuclei, with a delicate reticulum between. They grow in the periosteum, also in the breast or testis, and the corresponding lymphatic glands soon enlarge. The prognosis after amputation or excision, even when including that of the lymphatic glands, is very bad.

*Small round-celled sarcomata.*—These tumours are composed of small round cells, consisting of a deeply-staining nucleus with little cell protoplasm around. The cells resemble superficially those of lymphatic gland tissue. Between the cells is a delicate reticulum consisting of stellate cells with oval nuclei and interlacing fibrils, in which blood-vessels run. The growing margin is surrounded by œdematous inflammatory tissue. The cells of the tumour tend to infiltrate surrounding tissue, to spread along intermuscular planes, or to

bore into a large vein and extend rapidly along the lumen as a malignant thrombus.

This sarcoma originates in connective tissue, lymphatic glands, tonsil, spleen, thymus, etc. A small round-celled sarcoma has to be distinguished from lymphadenoma and tuberculoma.

(*b*) *Spindle-celled sarcomata.*—Spindle-celled sarcomata are made up of spindle-shaped cells of various sizes, so that one can speak of a large and a small spindle-celled sarcoma.

The cells are arranged irregularly in bands, not in whorls as in fibromata, and only a few nuclei exhibit mitosis. A very small amount of intercellular substance separates the cells, and this is mainly homogeneous or faintly fibrillar, and shows a very few thin-walled capillary vessels. These growths may be enclosed by an inflammatory capsule and separate easily from surrounding structures. On section they appear pinkish or greyish-white. Their usual seats are subcutaneous tissue, fasciæ, tendon sheaths, and periosteum. The growing margin is apt to show rapidly-dividing cells, oval or round, infiltrating surrounding parts.

If shelled out they recur *in situ*, "recurrent fibroids." If this happens a more free removal, involving a zone of normal tissue, should be at once undertaken. Should this not be done there is danger of fungation and of metastases, which often grow more rapidly than the primary tumour. They have to be distinguished from gummata.

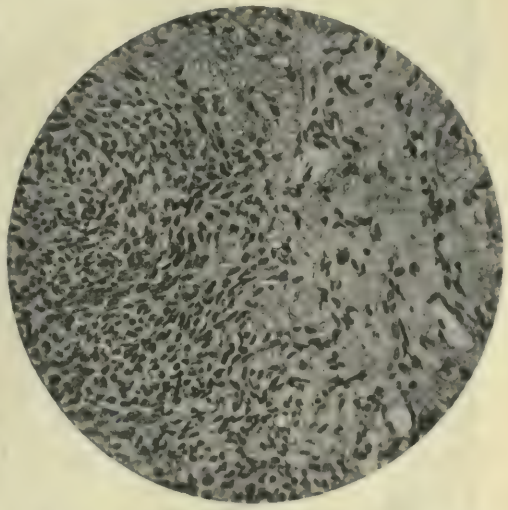


Fig. 12.—Fibro-sarcoma undergoing myxomatous degeneration.

(*c*) *Myelomata, Giant-celled or myeloid sarcomata.* — A myeloma is a tumour composed of round, oval and spindle cells in various proportions, but characterised by exhibiting a number of giant multinuclear cells like the osteoclasts of bone.

These peculiar cells are irregular masses of protoplasm containing as many as thirty oval nuclei, and have their origin in the giant-cells of bone marrow. They are held to indicate slow growth, and so a relatively favourable prognosis. They differ from the giant-cells of tubercle in having the nuclei scattered throughout the cell; also there is an absence of caseation.

The myeloid sarcomata of bone grow from the marrow and form elastic or soft jelly-like tumours, exhibiting on section a maroon or livid crimson colour, not unlike the muscular tissue of the mammalian heart, with a smooth, shining surface blotched by patches of blood extravasation. As they grow the inflammatory zone around them absorbs the normal bone, whilst forming fresh periosteal bone on the surface, so that the tumour appears to be enclosed in a shell. Having broken through the shell, the tumour begins to spread amongst the muscles, with blood extravasation. Ultimately it will reach the

skin and fungate. Only after a long time, if at all, does metastasis occur, and then only a single tumour may arise, having the characters of the primary growth. These tumours in bone have been renamed myelomata with the object of removing them from the class of sarcomata; but, both on pathological grounds and clinical convenience, it seems best to continue to regard them as a favourable type of sarcoma.

There is a great tendency to myxomatous degeneration and blood extravasation. Indeed, the whole tumour may become a blood-cyst, and, communi-

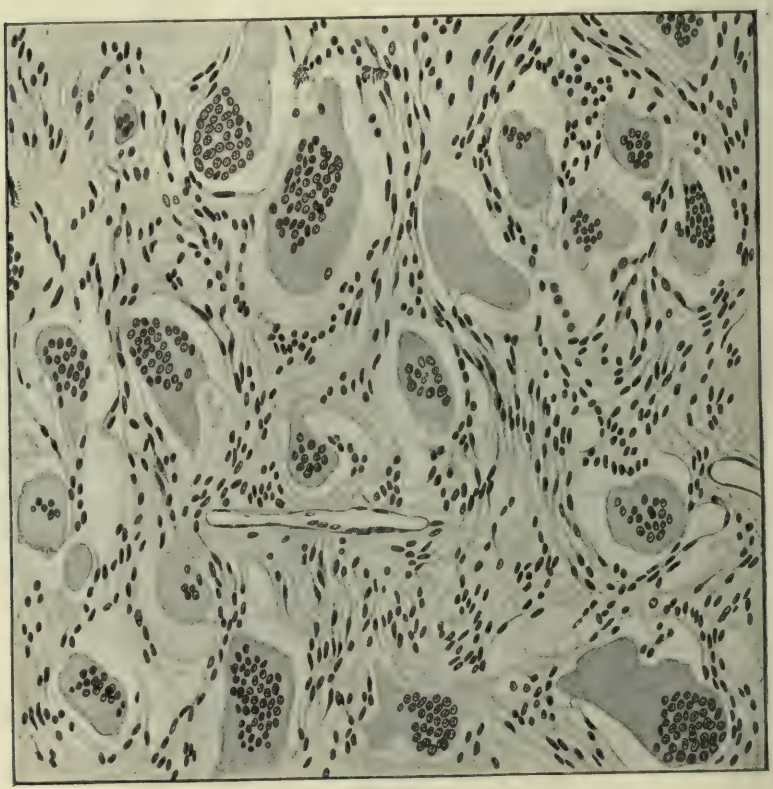


Fig. 13.—Myeloma. Drawing of a section under high magnification

cating with the blood-vessels, it may pulsate, and give rise to one form of bone aneurysm.

*Mixed-celled sarcomata.—Chondro-sarcoma, Osteo-sarcoma, Myxo-sarcoma.*—Sarcomata may show in various parts oval, spindle, round, and multinucleated cells. In addition, degenerations may occur. Myxomatous degeneration gives rise to cysts containing serum, mucin, or blood. In the case of bone tumours, cartilage or bone in the tumour may possibly be derived from cartilage or bone cells; but these forms may appear unconnected with bone. A hyaline homogeneous substance collects between and separates the cells, and in this ossification may follow; or the calcification and ossification may proceed directly, as in the normal formation of bone in membrane. The presence of cysts, of cartilage or of bone in a tumour is so far favourable as regards prognosis in that it shows that the growth must have developed slowly. On the

MELANOTIC SARCOMA.

Multiple metastatic tumours growing in the skull, secondary to a melanotic sarcoma in the skin of the back. (St. Bartholomew's Hospital Museum.)

other hand, the growing margin of the tumour may exhibit rapidly-dividing round cells.

2. **Sarcomata showing peculiar features.**—*Melanotic sarcoma or Melanoma.*—This tumour is peculiar in that its cells contain pigment, melanin, giving to the tumour a black or greyish-black appearance. The pigment is seen *in* the cells as sepia-brown or yellow-brown granules, or as a diffuse yellow-brown staining. Some of the tumours have the general structure of a round-celled sarcoma, others an alveolar arrangement.

The growth spreads outwards from the centre along lymphatic channels,

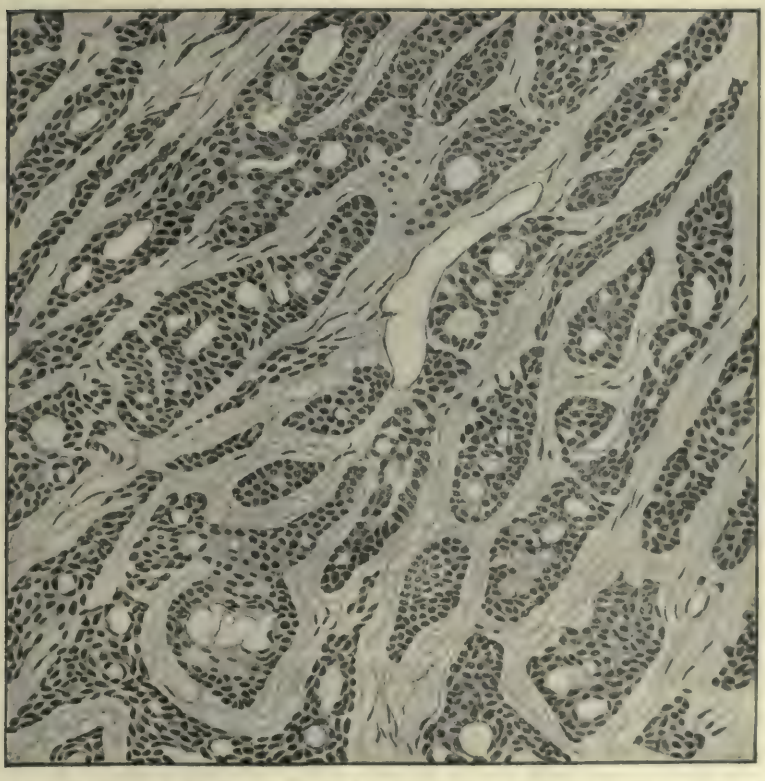


FIG. 14.—Drawing of a section of an endothelioma of the parotid gland. The vacuolation, with here and there colloid material in the spaces, of the columns of endothelial cells is well shown.

infiltrating the walls of the lymphatics and veins. Emboli pass by the lymphatics to the neighbouring glands, from which the disease spreads to the tissues around the glands. By entering veins and the general circulation metastases arise early.

Melanotic sarcomata grow from the uveal tract in the eye, from pigmented moles of the skin, in the scars of punctured wounds, and on the tips of the fingers and toes, perhaps following pricks. The palate, which in Lascars, as in some dogs, is pigmented, may be the seat of a very malignant growth. Melanomata are very common in grey horses, originating round the anus.

There is a great tendency to early metastasis, which appears at one or two points in lymphatic glands, or in the liver, or secondary growths develop from

an infinite number of small points in the skin or on a serous surface. When the patient begins to suffer from infiltration of the liver the pigment may be found in the urine.

The tendency to early infection of lymphatic glands and their alveolar arrangement has led to some tumours being regarded as carcinomata. A melano-carcinoma has been traced to the tubular ciliary glands (Treacher Collins).

*Chloroma* is a form of small round-celled sarcoma, which grows in the periosteum of the frontal and facial bones from one or more centres, is attended by marked anæmia and increase of lymphocytes, and quickly gives rise to petechiæ and to metastases. It is so named from the peculiar grass-green colour of the tumours, both primary and secondary, as seen through the skin during life and on section after death, but which fades on exposure, whilst the rest of the body is not similarly pigmented. Nothing can be done to arrest the rapid growth.

*Psammoma, or sand tumour,* is a fibro-sarcoma growing in the meninges, vascular plexuses, or pineal body, enclosing peculiar concentric grains of calcareous material, due to its deposition in connective tissue and blood-vessels which have undergone hyaline degeneration.

### *Endotheliomata.*

Endotheliomata may be innocent or malignant, and new growths formerly called alveolar or tubular sarcoma, lymphangiosarcoma, hæmangiosarcoma, have been grouped together with others under this heading because they are held to spring from endothelium of lymphatic or blood capillaries. The tumours may resemble sarcomata in their clinical course, although their cells have an epithelial-like character, and are arranged in an alveolar or tubular manner. Between the strands or masses of cells is formed a more or less vascular connective tissue.

*Vascular endotheliomata* are believed to arise from the endothelium of blood capillaries. They exhibit spaces containing blood, surrounded by masses or strands of cubical, polyhedral or cylindrical cells. Between are newly-formed tortuous blood-vessels. Such tumours are exceedingly vascular.

*Lymphatic endotheliomata* are traced to the endothelium of lymphatics. In them rapidly-dividing endothelial cells form strands or masses enclosing spaces. Whether by secretion on the part of the endothelial cells, or owing to their degeneration, there collects a glistening white hyaline material which superficially resembles hyaline cartilage, but differs from cartilage in its microchemical reactions. It readily liquefies, and the spaces dilate into cysts. The stroma is composed of connective tissue which is not vascular. But a mixed vascular and lymphatic endothelioma may occur.

Vascular endotheliomata are met with in vascular organs, in testes, bone, thyroid, liver, also in sacrococcygeal and other teratoid tumours. Lymphatic endotheliomata grow on serous surfaces, in connective tissue, in congenital malformation, moles and warts, also in the salivary glands, especially the parotid. Malignant endotheliomata infect the neighbouring lymphatic glands early and widely.

## (B.) **Epithelial Tumours.**

Epithelial tumours are new growths composed of the epithelium of surfaces and of glands, together with vascular connective tissue. The connective tissue forms either a framework for the covering epithelium or a stroma or network in

the meshes and spaces of which the epithelial cells are placed. They are divided into the *benign* tumours (papillomata, adenomata) and the *malignant* (carcinomata, including the epitheliomata). But the two divisions are not sharply distinguished; whilst the former are circumscribed and produce no metastases, and the latter infiltrate and undergo metastasis, yet papillomata and adenomata may show a change in the rapidity of increase and extension of epithelial cells so as to become carcinomata.

### *Benign Epithelial Tumours.*

**Papillomata, warts and villous tumours.**—Papillomata resemble in structure the papillæ of the skin and the villous processes of mucous membranes. They have a framework of connective tissue covered by epithelium. The papillæ are branched and higher than normal, and the epithelium is thicker. The connective tissue surrounds one or more blood-vessels, a branch from which passes into each process; the epithelium is sharply separated from the connective tissue, into which it does not penetrate. These growths are broad-based or sessile on the one hand, or pedunculated and much branched on the other. They are liable to ulcerate and bleed, and, in older people especially, may be gradually transformed into carcinomata by the epithelium growing downwards into the connective tissue.

FIG. 15.—Papilloma from the mouth.

**Varieties of papillomata or warts.**—1. *Congenital hard pointed warts*, or *ichthyotic warts*, are horny papillomata, which may be seen on the skin or tongue of children, and may co-exist with horny patches of skin. The wart is made up of thickened layers of horny epithelium.

2. *Congenital soft, flat warts* are either reddish, or blackish from pigment, in addition to which they may have hair. They are formed of epithelial-like cells ranged somewhat in columns vertical to the surface, covered by normal epidermis. Some have hair follicles and melanotic pigment, forming hairy and pigmented moles. Regarding the cells as endothelial, these moles have been given the name of lymphangioma hypertrophicum; if a malignant change ensues a new growth of a connective-tissue type, sarcoma, melanotic sarcoma, or endothelioma may be anticipated.

3. *Infective warts.*—These, which are frequently seen on the hands of children, are inoculable not only on the same individual but on others. They are doubtless due to an infective organism; they have only a limited course, hence the notion that they can be charmed away, but they tend to recur.

Venereal warts may be syphilitic condylomata, flattish elevations of the skin or mucous epithelium due to swellings of the papillæ, and producing an infective exudation.

Gonorrhœal warts differ from syphilitic condylomata in being pointed. They are inflammatory hypertrophies of simple and compound papillæ occurring on the skin and mucous margins of the penis and labia. They are a source of gonorrhœal infection in general and of similar warts in particular. When larger they assume the appearance of a cauliflower. Inflammatory warts of a like character occur on the penis of dogs and in the vagina of bitches, being transmitted by direct inoculation.

"Anatomical warts" occur on the hands of dissecting-room porters and morbid anatomists, and are a chronic form of tuberculosis.

FIG. 16.—Fibro-adenoma. Photograph of a section through an enlarged prostate. Alveoli, which are distended owing to obstruction of ducts, are surrounded by an increased amount of inter-alveolar fibro-myomatous tissue.

4. *Irritation warts*, the exciting agent of which is doubtful, are more liable to occur with increasing age, and have a tendency to terminate in epithelioma; under this heading may be noted soot warts on the scrotum and elsewhere of chimney-sweeps, and on the hands of gardeners; the warts occurring on the tongue as a result of irritation by tobacco, and on the hands of those exposed to the X-rays, and on the face after sunburn.

5. *Senile warts* appear as brownish elevations about the back, neck, and arms of old people.

6. Soft *mucous papillomata* occur in the rectum of children, and perhaps, when arising at the junction of the anus and rectum, may be considered a congenital *rest*.

In the bladder papillomata may arise without evidence of previous irritation, may multiply over the bladder wall by inoculation, and are new growths with an ultimate tendency to become malignant. The larger ones, from the resemblance to the villi of the chorion, have been called villous growths. But papillomata may also arise from continued irritation, such as is produced in the bladder and rectum by *bilharzia*, in the urinary tract by a calculus or foreign body. They occur in the larynx, due to irritation after diphtheria, etc., also around a tracheotomy tube, and as sessile nodules in the case of "voice users." However delayed, in the end a malignant change sets in.

7. Papillomata arise in the interior of cysts and in cystic tumours of the breast or ovary.

**Adenomata or glandular tumours.**—*Adenomata* form circumscribed, mainly encapsuled, growths in the skin, mucous membranes or glands. They do not infiltrate nor form metastases; therefore they are regarded as

benign tumours. They are characterised by a new formation of glandular structure from pre-existing gland tissue, but they do not form true ducts, nor secrete. They are divided into the *acinous* variety, consisting of groups of acini lined with spheroidal epithelium and communicating with one another, and into the *tubular* variety, in which the epithelium is more columnar. They possess a connective-tissue stroma, partly of pre-existing, partly of newly-formed material.

Adenomata arise sometimes in normal, sometimes in malformed glands, sometimes in glands previously inflamed, *e.g.*, a cirrhotic liver, a granular kidney, an ovary with scars; sometimes they are derived from fœtal remnants.

*Clinical varieties.—Tubular adenomata* occur in mucous membranes and tubular glands, such as those of the intestine and uterus; also in the ducts of the breast, liver, kidney and ovary. They consist of simple and branched cylindrical tubes lined with cylindrical or cubical epithelium, forming tumours varying in size from a pea to a fist. By projecting above the surface they come to be classed as papillary growths and polypi.

*Acinous* or *alveolar adenomata* arise in glands, such as the breast, the thyroid and sebaceous glands. A number of grape-like acini are connected by a duct-like channel. The *papilliferous adenoma* is formed by papillomatous growths, projecting into the alveolar spaces and filling them with intra-cystic growths. If the connective-tissue stroma is well developed, the tumour may be hard and form a fibro-adenoma around the canaliculi in the breast, or it may be soft and vascular in the thyroid gland. The connective tissue may undergo myxomatous degeneration, *myxo-adenoma*, or cysts may develop in it, *cysto-adenoma*.

Adenomata cannot be sharply differentiated from carcinomata. The cancerous character of an adenomatous tumour is recognised by marked epithelial proliferation and infiltration. Thus, in the intestine a tubular growth of a single layer of columnar epithelium, when it infiltrates the connective tissue and muscular wall, is recognised as carcinoma. But there may be marked epithelial proliferation in the case of adenomata of the breast and uterus for some time without penetration of the basement membrane and infiltration of the connective tissue.

### *Malignant Epithelial Tumours.*

**Carcinomata.**—Carcinomata are composed of epithelial cells contained in a framework of connective tissue; they have an alveolar arrangement, and are characterised by infiltrating indefinitely beyond the tissue in which they originate and by forming metastatic growths in distant organs. The alveolar arrangement shows some resemblance to the normal structure in which the growth arises, and the cells of the cancer may still contain secreted material; yet the arrangement of the alveoli is abnormal, no ducts are formed, the epithelial cells are atypical and out of place, and there is no regular secretion. Gastric and pancreatic carcinomata have resemblances to the normal structure of the stomach and pancreas, and their cell masses contain peptic and tryptic ferments respectively, which prove active in an artificial digestion mixture. Carcinoma of the thyroid resembles to some extent the normal gland, and cachexia strumipriva having supervened upon the excision of the whole gland, the development of metastatic growths with the structure of the primary tumour has then been followed by a disappearance of this cachexia.

*General origin.*—Carcinomata arise from the proliferation of pre-existing epithelium in connexion with : 1. Skin, mucous membrane, and glands, apparently unaltered before the commencement of the carcinoma ; 2. Skin, mucous membrane, and glands, previously altered by inflammation ; 3. Previously-existing benign growths, adenomas, papillomas, cysts ; 4. Remnants of fœtal structures and misplaced epithelial masses ; 5. Epithelial cells of the chorion and placenta.

The epithelial cells are descended from epiderm or epiblast, and hypoderm or hypoblast, but also from mesoderm in the case of the ovary, uterus and tubes, kidney, bladder, prostate and suprarenal capsule.

*General development.*—The epithelium commences to proliferate so as to form more layers than normal, although this may happen without the disease being malignant, as in the case of a papilloma or adenoma or even of chronic inflammation. The characteristic commencement of carcinoma is the breaking through the wall of the alveolus or duct, or the basement membrane of the skin or mucous membrane, and the *invasion by the epithelial cells of the surrounding and underlying connective tissue.* These epithelial cells, now out of place in the connective tissue, continue to proliferate, forming spherical, oval, tubular or flask-shaped masses. They may be arranged around a cavity like an alveolus, or as if lining a tube, or in concentric layers to form cell-nests. They soon break into the lymphatic spaces, where they form thrombi. The growth extends radially out from the centre in all directions, spreading along the walls of the lymphatics, and particles are carried, like emboli, to the neighbouring lymphatic glands. The epithelial cells develop, following as their type the epithelium from which they spring. Around the growing margin of the epithelial mass is set up inflammation ; a small-celled infiltration precedes the growth, some cells being leucocytes ; others are fibroblasts from which a variable amount of connective-tissue stroma is developed, enclosing the epithelial cells Blood-vessels form in this stroma and are numerous at the periphery of growing tumours. Where the fibrous stroma is in excess they are few, and becoming obliterated later on lead to degeneration. Meanwhile the invaded tissue disappears before the epithelial growth and the surrounding inflammatory zone, none of it remaining ; even the more resistant tissues, such as bone and cartilage, are rapidly eroded.

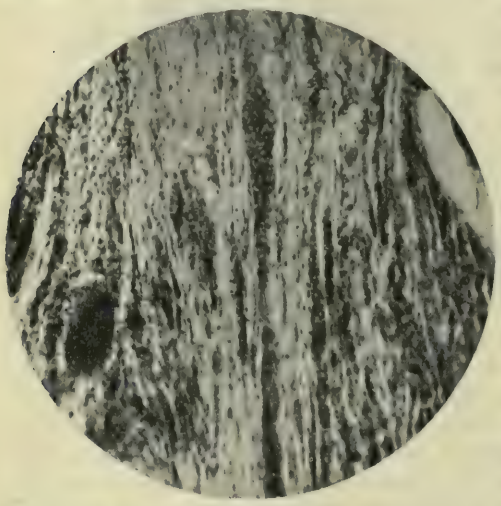


FIG. 17.—Spheroidal-celled carcinoma, spreading by the lymphatics. Photograph of a section through the pectoralis aponeurosis midway between the breast, enlarged by carcinoma, and the axilla. Rows of rapidly-dividing spheroidal cells fill the lymph-spaces.

A naked-eye section of a carcinoma gives an appearance varying between a densely-fibrous non-vascular growth and a soft, brain-like or medullary

structure with its outer zone very vascular. From the surface of the section can be scraped a juice showing epithelial cells more or less degenerating. No sharp line of demarcation nor capsule limits the tumour from the surrounding healthy tissue, nor is the boundary a regularly curved outline. The growth must be considered to extend for at least 1—2 cm. into the apparently quite healthy tissues, and often much more.

On the surface of the skin or a mucous membrane the growth may present a spongy, papillary, polypoid, cauliflower-like appearance, but this is combined with an infiltration of the tissues around its base.

*Degeneration.*—Carcinomata of the skin and mucous surfaces, and those which ultimately reach the surface, ulcerate and fungate, whilst suppuration extends into the deeper parts. Rapid destruction goes on, with hæmorrhages, and the patient suffers from septic absorption. Both clinically and microscopically the inflammation may obscure the signs of the new growth and render the diagnosis difficult.

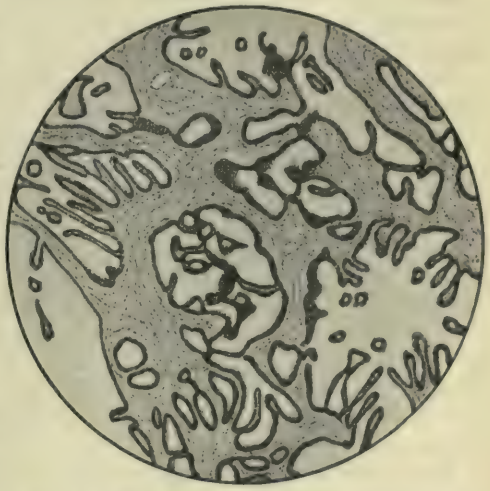


FIG. 18.—Section of a villous carcinoma or "duct-cancer" of the breast. The slender, anastomosing intra-cystic processes in the cavities are clothed with a short columnar epithelium.

Fibrous degeneration, and even calcification, may occur in slow-growing or scirrhous cancers. In other cases, owing to the diminution of the blood-supply, a myxomatous, colloid, hyaline or gelatiniform degeneration occurs. The epithelial cells swell up from the formation of mucin or a mucin-like body, become vacuolated, or replaced by a glistening, semi-translucent, jelly-like substance, whitish or brownish—hence the term *colloid;* but the substance is not the same as that found in the thyroid gland. This fluid presses the cells to one side, or the cells disappear, leaving their nuclei, or a reticular formation develops by the cells being separated from one another. Cysts form, especially in the case of the ovary. This myxomatous or colloid degeneration is common in cancers of the stomach and intestinal tract, omentum and ovary, and is found occasionally in those of the breast.

*Carcinoma in lymphatic glands.*—Epithelial cells broken off from the primary cancer reach the neighbouring lymphatic glands, and being there arrested in the lymph sinuses begin to proliferate rapidly, so that from one or more foci the whole gland is replaced by carcinoma. The capsule is broken through, and the growth spreads into the neighbouring connective tissue, where, meeting similar processes from neighbouring glands, the whole becomes matted together into a diffuse mass, which later extends and invades neighbouring important structures. The adventitia of large vessels presents some resistance, but the cancer penetrates their walls by way of the vasa vasorum; or reaching the skin, it ulcerates and fungates.

*Metastases or secondary growths.*—Tumours corresponding in structure and

general character with the primary growth appear in internal organs such as the lungs, liver, bones, or on distant points of the skin, less commonly on mucous membrane. They may appear singly, but generally are multiple. It has been shown experimentally, by crushing, that cells such as those of the liver, bone-marrow and placenta may get into the circulation and be carried to some distant part. Metastasis takes place especially through the lymphatics, by way of the neighbouring lymphatic glands; but carcinomata, especially the more malignant varieties, also break into veins, and so reach the circulation directly. Whilst sometimes the growth extends by direct continuity, yet in most cases the epithelial cells, like emboli, pass through long distances of the lymphatic circulation, the thoracic duct, the pulmonary circulation, and far along the arteries, before being arrested. The immediate cause of the arrest which gives rise to the metastatic growth is unknown. It has been conjectured that numerous cancer cells get into the blood stream and are destroyed, the metastases representing cells which have escaped destruction. Generally there is a secondary tumour which grows from a focus by extension in all directions, but in cancer of the tongue it may occur as a diffuse infiltration of the neck, or in the breast the so-called cancer *en cuirasse.*

*General course of carcinoma.*—The patient may suffer little or nothing at all in the early stages of a primary growth. This is so often the case that it presents the greatest obstacle to early and timely removal, in that the growth is unnoticed until too late for a cure. If on the surface, the tumour is noticed by chance or by a slight pain. The more deep-seated the tumour the longer does it escape recognition. When some special symptom is set up, such as obstruction of the alimentary canal, the growth has been without doubt present for many months, and then may be too extensive for removal. Even when attention has been drawn to the part by chronic inflammation in the case of the tongue or cervix uteri, it is difficult for some time to be sure that carcinoma has supervened.

Whilst it is generally the case that carcinoma causes no marked symptoms until either metastases form or ulceration and septic absorption occur, there takes place early a loss of weight. The primary growth, its extension in lymphatic glands, or the metastatic growth, may all give rise to some complication, such as intestinal, portal, biliary, or urinary obstruction, to spontaneous fractures of bones, to hæmorrhages on surfaces, cutaneous or mucous, or into serous cavities; pain is set up either by involving some special nerve or by general infiltration in a sensitive part. As soon as septic absorption occurs there commences the rapid impairment of health known as *cancerous cachexia, i.e.*, anæmia with rapid wasting. The skin becomes sallow, has an earthy look, minute angiomata or spider nævi appear, the face is careworn and anxious, the body emaciates, the strength fails, and the patient dies exhausted.

*Anomalies in the clinical course of malignant disease.*—Malignant disease usually pursues a steady course towards a fatal issue; exceptionally, however, it behaves in quite an anomalous manner. Thus it may spontaneously disappear by a process of atrophy and absorption, leaving behind merely inflammatory scar-tissue, or it may become quiescent or shrink for a time, and after a while begin to grow again. Further, after the removal of the primary disease, although it is the rule, if it recur, for it to do so quickly either in the scar, neighbouring glands, or internal organs, yet occasionally there is no return for long periods, such as nine years in the case of the larynx, and fifteen to thirty in the breast. Hence the dictum, that if there is no recurrence

after three years a cure may be claimed, must be accepted with reservation. Again, although it is usual for a recurrent growth to have the same structure as and run a similar course to that of the primary disease, at times it may have a different structure, and may be merely of the nature of an inflammatory new formation; even when the microscope has shown it to have a malignant character, it may yet suddenly cease to grow or undergo atrophy and disappear. Such anomalies justify to a certain extent a surgeon in not committing himself too absolutely to the diagnosis of cancer in the patient's hearing, although they are too infrequent to influence his practice. They also account for the successes claimed for the many so-called cancer cures.

**Varieties of carcinomata.**—The carcinomata are divided into four classes,

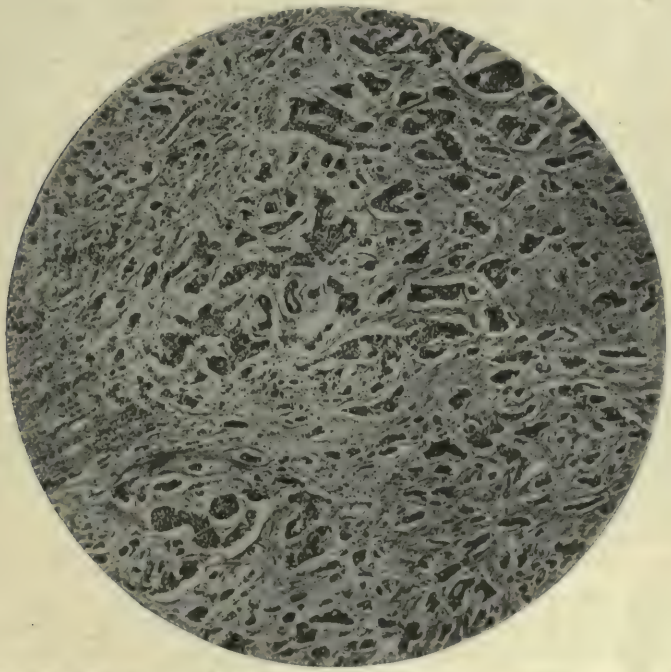


FIG. 19.—Hard spheroidal-celled or scirrhous carcinoma. Photograph of a section through a cancer of the breast.

in accordance with the shape of the epithelial cells and their structural arrangement:—

1, Spheroidal-celled or acinous carcinomata; 2, Columnar-celled or tubular carcinomata; 3, Squamous-celled carcinomata, in relation to which the term epithelioma is more particularly used; and, 4, Rodent ulcer.

1. **Spheroidal-celled or acinous carcinomata.**—The epithelial cells are spheroidal in shape, growing in connexion with racemose glands, the character of the epithelial cells and the acinous arrangement of the particular gland being retained by the primary and secondary growths, although in an atypical fashion. They vary pathologically according to the amount of fibrous stroma, and clinically according to the rate of their course.

(*a*) *The scirrhous or hard spheroidal-celled carcinomata* exhibit a large amount of fibrous stroma, which may be in such quantity in the centre of the growth that the latter appears to consist of little else, except for a few cells

some of which may be undergoing fatty degeneration, between the fibres. But at the growing margin the acinous structure is more apparent, and an epithelial invasion of the surrounding tissues, preceded by a small cell infiltration, is seen in progress. Clinically such tumours are hard and nodular; in consequence of the shrinking of the fibrous tissue there is puckering of the skin, or constriction of surrounding parts; hence the nipple is retracted in scirrhus of the breast. On section the tissue creaks under the knife, and the section appears concave. Such tumours generally grow slowly, so that the primary growth remains small, and in the extreme form of atrophic scirrhus may become almost stationary or even get less by fatty degeneration. But the slowness of development of the primary growth does not extend to lymphatic and secondary infection. Lymphatic glands, although not markedly enlarged, are found when exposed to be very hard and shotty, owing to infiltration, and metastases of a similar character develop in the liver, bones, etc., and cause death at an early date. Exceptionally, however, the lymphatic infection and the development of metastases are indefinitely delayed. If the tumours reach the surface they form chronic ulcers with indurated edges and a base composed of the new growth covered by granulation cells, giving rise to a few pus corpuscles and a thin, sanious discharge.

(*b*) *The encephaloid, medullary, or soft spheroidal-celled carcinomata* show a scanty amount of very vascular fibrous stroma; the cells in the large alveolar spaces are in several layers. At the margin the epithelial cells are proliferating rapidly and spreading into the surrounding tissue, which disappears before the invasion, whilst there is around the growth an œdematous inflammatory zone. The tumours are soft, elastic, "semi-fluctuating"; the surface of a section appears greyish or creamy-white blotched with blood; hence arises the name *encephaloid*, brain-like, or *medullary*, marrow-like. Towards the centre the substance is liable to fatty degeneration, so that it becomes almost diffluent, and hæmorrhagic extravasations from the giving way of blood-vessels are frequent. These tumours quickly tend to fungate, suppurate, give rise to hæmorrhages, and also to a foul discharge. Generally they grow rapidly, spreading to the surrounding parts, and infecting lymphatic glands, thus forming an ill-defined mass which quickly breaks down. Metastases starting in numerous foci rapidly develop in the lungs and liver.

Between the scirrhous or hard variety and the encephaloid or soft there is no hard-and-fast line to be drawn in practice, and the characters of individual cases make it often impossible to classify the tumour in one category or the other. In the case of the breast definite instances of scirrhous or encephaloid cancer are common; this is not so in other parts. Even in the breast a primary scirrhus may give rise to soft rapidly-growing metastases.

2. **Columnar-celled or tubular carcinomata.**—The epithelial cells are columnar or cylindrical, growing from columnar epithelium, tubular glands, and the ducts of the racemose glands. They consist of irregular tubes lined with columnar epithelium. In the more slowly growing there is a regularly-arranged, single row of distinctly columnar cells enclosing a central lumen; in the more rapidly growing, several layers of more cubical, or almost spheroidal, cells nearly or quite fill the central space. Around the epithelial cells is an alveolar arrangement of fibrous tissue, which may be very small in amount in the soft varieties, or more extensive, as in the annular carcinomata of the intestinal tract; or there is diffuse infiltration and thickening, as in the wall of the stomach, which in these circumstances has been compared to a leather bottle. Papillary or cauliflower-like outgrowths are met with in the villous tumours of the rectum and bladder, and papillary ingrowths into dilated

ducts are seen in duct cancer of the breast. These growths rapidly break down, giving rise to hæmorrhages and a foul discharge.

On the whole, the primary growth remains a local disease longer than the spheroidal-celled acinous carcinoma, the lymphatic glands are not so soon infected, metastases form later, and are fewer in number. Thus duct-cancer of the breast is a more favourable, although a rarer, growth than scirrhus.

Cancers of the rectum and intestine are also favourable, and lend themselves to removal in older patients, but in patients below forty they are very malignant. Extreme malignancy nearly always marks the course of a cancer of the pancreas. Complications in connexion with the primary growth are frequent—pyloric, biliary, intestinal and pancreatic obstruction, ulceration, and hæmorrhage from the bladder and rectum—and these along with septic infection are frequently the cause of death, before the lymphatic glands are markedly infected or metastases have developed. The feature of these carcinomata is the difficulty of distinguishing them from inflammatory lesions during the earlier stages. Occasionally a secondary growth comes into prominence, whilst the primary focus escapes notice, so that a malignant mass in a bone is found to present the peculiar structure of an intestinal carcinoma.

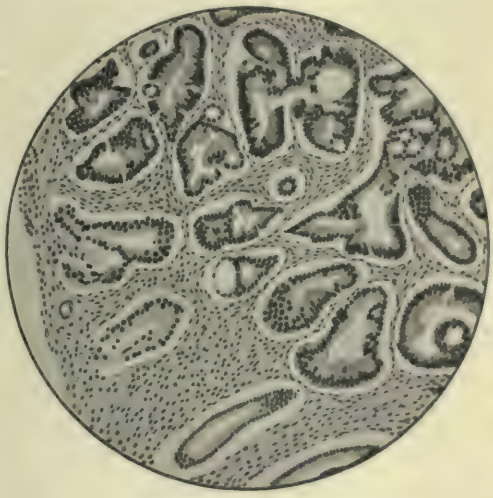


FIG. 20.—Section of an Adenoid Carcinoma of the Rectum, showing irregular gland tubules, lined by columnar epithelium. Goblet cells are absent.

*Carcinoma of the Chorion. Deciduoma.* — Hydatid moles arise in the uterus from myxomatous degeneration of the chorionic or placental villi, causing them to swell up into small cystic bodies united by delicate connective tissue like a mass of grapes. The villi show, in addition, a certain amount of proliferation. These ectodermal cells of the chorionic and placental villi, especially the cells of the syncytium in the neighbourhood of the attachment to the uterine wall, may proliferate and grow into the blood spaces forming thrombi, invade and replace the entire wall by a most rapid carcinomatous new growth, and then give rise to metastases.

3. **Squamous-celled carcinomata, especially called epitheliomata.**— These are composed of cells resembling stratified epithelium, and grow from the skin and mucous membranes covered by stratified squamous epithelium, also from similar epithelium lining dermoid cysts and other epithelial remnants. They are more especially common in the neighbourhood of the junctions of skin and mucous membrane, as the result of chronic irritation. The cells of the rete Malpighii, especially those lying between the papillæ, grow downwards as flask-shaped processes into the underlying connective tissue. In chronic irritation the papillæ are often much elongated, and the interpapillary processes descend further, but there is no actual invasion of the

connective tissue. In squamous-celled carcinoma the flask-shaped down-growths branch and give off isolated clumps and masses of epithelial cells amongst the connective tissue, or the masses of epithelial cells follow the lymphatic channels and become moulded into tubular masses, or form rows of cells between muscle fibres. The cancer cells become surrounded by a small round-celled infiltration.

*Epithelial cell-nests* (Fig. 21).—There are found, both in the epithelial down-growths and in the epithelial islets and tubular masses developing beneath the epithelium, collections of cells arranged concentrically, like the layers of an onion. An excessive formation of corneous cells takes place towards the centre of the sphere, instead of towards a surface as usual. Thus the cells nearest the centre are the most scale-like and compressed, the outer ones polyhedral or cubical, and the most external of all cylindrical, like the cells of the rete Malpighii. The polyhedral or cubical cells show granules of keratin like the stratum granulosum ; the scale-like cells result from a further kerato-hyaline change of the albumen, causing the cells to stain deeply with a ground stain like fuchsin, whilst the logwood staining of the nuclei is lessened. The centre of these *epithelial nests* or *pearls* may consist of a glistening, concentrically striated, or homogeneous mass, devoid of nuclei, of a horny character. Liquefaction follows, giving rise to small cysts. These cell-nests, or horny epithelial pearls, are not, however, necessarily found in squamous-celled carcinoma, and similar bodies may be seen in other conditions in connexion with normal skin, in the stratified epithelium of mucous membranes, in the tonsils, in non-malignant scars, and even in papillomata, but then always in direct connexion with the surface epithelium. From this it follows that it is not essential for cell-nests to be found in scrapings or small pieces in order to diagnose epithelioma, and conversely, the finding of a cell-nest does not prove that squamous-celled carcinoma is developing in the tissue examined.

Although it is not a new growth, *Cholesteatoma* may be mentioned in connexion with the subject of "cell-nests." It consists of a pearl-like mass of squamous epithelial cells, concentrically arranged, and often containing cholesterin, bacteria and cellular débris. It is found in the middle ear in cases of long standing chronic suppurative otitis media with perforation of the tympanic membrane. Its pathology and treatment are discussed in Section IX., at p. 472.

Besides growing downwards, a squamous-celled carcinoma also proliferates on the surface with the formation of a papillated or warty surface ; or it may grow from an already existing papilloma, by the cells of the latter rapidly proliferating to form several layers and then growing downwards into the connective tissue beneath. The surface of an epithelioma quickly ulcerates and breaks down, forming an ulcer covered by granulation tissue, but its base and margins are composed of carcinoma.

In chronic inflammation of an epithelial surface there may be excessive thickening of the epithelium, leucokeratosis or leucoplakia of the tongue for instance, but all the changes for a time go on above the connective tissue, which is only infiltrated by leucocytes. The papillæ may be elongated upwards and downwards, but the commencement of the malignant change is marked by the down-growth of epithelial columns, which branch in the sub-epithelial tissues.

*Clinical course.*—A squamous-celled carcinoma may commence as a warty tubercle, which then becomes an ulcer with raised, everted, sinuous, indurated edges, and a hard, warty irregular base, whilst the tissue around is more resis-

tant, and the lymphatic glands become hard and enlarge. At another time it begins by the induration of the base and edges of a chronic ulcer, the latter becoming everted and the discharges more profuse and foul. A long-existing crack or fissure, or the granulations round the orifice of an old-standing sinus, may begin to fungate, or a puckered scar becomes red, indurated, then ulcerated. Unless an epithelioma is removed early, an infection of the lymphatic glands, corresponding to the part, ensues, whilst there is less tendency than in spheroidal-cell carcinoma for the cells to be arrested and to form thrombi in the lymphatics. Indeed, at an early stage there is a distinct difference in this respect; the squamous cells pass like an embolus along the lymphatics only to be arrested in the gland, so that the part between the primary growth and the enlarged gland may be free from disease. The

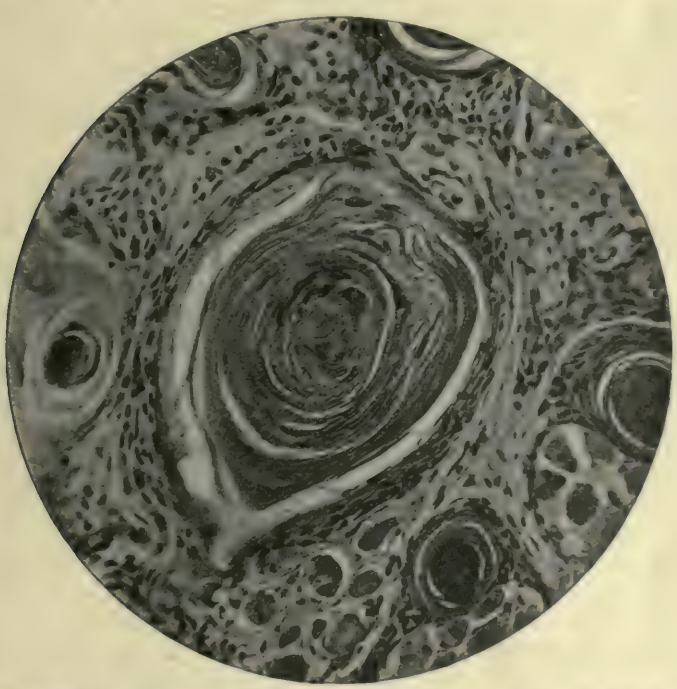


FIG. 21.—Epithelial cell-nests or pearls. Photograph of a section through an epithelioma. A fully-developed cell-nest is seen in the centre, and around are several others less advanced, the epithelial cells showing kerato-hyaline changes.

epitheliomatous masses begin in the lympathic glands at one or more points, until the whole gland is occupied, and an extension follows. The mass soon softens and breaks down, probably favoured by septic absorption from the ulcerating primary growth. Dissemination very rarely occurs in internal organs or bones, then only at a late date. In epithelioma of the cervix uteri there is a great tendency to recur in the scar after excision.

Death usually occurs from complications connected with the primary growth or the enlarged glands, such as anæmia from hæmorrhage, bacteriæmia from ulceration, or involvement of neighbouring important structures.

Squamous-celled carcinomata are met with on the skin, lips, mouth, tongue,

pharynx, œsophagus, anus, cervix uteri, vagina, vulva, and penis. An exceedingly slow-growing type of epithelioma occurs on the skin of the scrotum, and one nearly as slow on the lip. Generally they arise in old age, and affect men far more than women. Should they appear in young adults, *e.g.*, on the tongue or in the scar of a burn, they run an especially rapid course.

4. **Rodent ulcer.**—The name *rodent ulcer* is applied to a locally malignant, epithelial new growth characterised by ulceration extending in a slow manner deeply as well as superficially, without invading lymphatic glands or giving rise to metastases. Usually attention is drawn to the disease when ulceration has already made some progress, but on inquiry it will be found in most cases that at the site of the ulceration there had existed beforehand a nodule covered

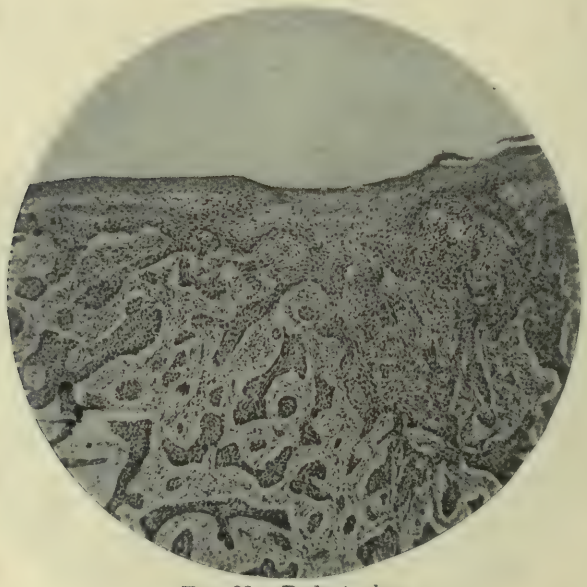


FIG. 22.—Rodent ulcer.

by thin but intact skin. This nodule is probably a congenital sebaceous adenoma, taking origin in a congenital *reste* connected with an ill-formed sebaceous gland. The cells composing the advancing portion of the ulcer resemble those of sebaceous glands; they are smaller and more spherical than those of squamous-celled carcinoma. They are grouped in flask-shaped masses, the epithelium around their periphery taking up a palisade-like arrangement, and are surrounded by a zone of inflammatory cells; the surface of the ulcer is covered by small round cells also. Cell-nests are absent.

The commonest seat for rodent ulcer is just below the inner canthus of the eye; less often it appears at other places on the forehead or face. It may be met with on the scalp, arms or breast. Generally it occurs in old people, and is single; but it may be multiple and occur before forty. First the nodule is covered by a scab, beneath which the ulcer forms; as it spreads its edges appear sinuous and a little raised, but neither indurated nor everted. The base is slightly depressed at first, then gradually becomes more excavated; it is pale, glazed and void of granulation tissue.

Extension goes on slowly, and in the course of years, the growth penetrates

to muscle and bone, which are eroded. Gradually the face, the eye, and the skull are perforated and the brain exposed. A deep chasm is formed, bounded by a narrow zone of the growth, from which there is continuous septic absorption, and when branches of the external carotid or the middle meningeal artery are invaded there are repeated hæmorrhages. Death follows from exhaustion.

**The Treatment of Cancer.**—1. The really successful practice as regards cancer is to *anticipate its onset* by removing the conditions which are now recognised as antecedents to it. Inflammatory lesions on the lip, tongue or cervix uteri may be arrested, or excised locally without causing deformity. Moles, warts and nodules on the skin, whenever they show any irritation, are at once cut out. The removal of a benign tumour from the breast or of gall-stones from the gall-bladder is an effectual means of preventing the onset of cancer.

2. The next best step is an early diagnosis that cancer has started. This is confirmed by the removal of *a piece of the growth for microscopic examination*, which may be done as a preliminary measure, but is better carried out at the actual time of operation, and the diagnosis made by immediate frozen section.

3. Cancer having definitely started, a *complete removal of the primary growth* is required. The real margin of the growth must be assumed to extend 1 to 2 cm. at least beyond the apparent margin, and in very malignant cases further still. The excision must be by cutting; no blunt methods nor tearing are admissible.

The character of the excision is dependent upon the particular nature of the growth, regard being also paid to its anatomical position. An excision of the primary growth as widely as possible is all that can be done in many situations. But in certain regions the excision can and must include the lymphatic glands draining the affected area.

4. *Excision of the primary growth along with the corresponding lymphatic glands* is carried out in one of two ways :—

(*a*) The first method rests on the assumption that the initial fragments detached from the primary disease, especially in the case of squamous-celled carcinoma, pass through the lymphatics to the lymphatic glands corresponding to the area without being arrested at any intermediate stage. Under this assumption a free removal by dissection of the lymphatic glands, whether perceptibly enlarged or not, at the same time as the primary growth, may suffice. In an early cancer of the lower lip it may be sufficient to dissect out the submental glands; in an early cancer on the side of the tongue, the glands from the submaxillary triangle, leaving intact the floor of the mouth; in an early cancer on the prepuce, the inguinal lymphatic glands on each side.

(*b*) The second method involves the removal *en masse* of the primary growth and the corresponding lymphatic glands, together with the intervening tissue, through which the lymphatics pass. This method rests on observations which show that the spread of the disease outwards from the primary growth takes place along the lymphatics and is attended by the arrest of cells to form thrombi in the lumen, the infiltration of the walls of the lymphatics and the tissues alongside. This is the operation required for spheroidal-celled carcinoma of the breast, columnar-celled cancer of the intestines, and for advanced cases of squamous-celled carcinoma of the tongue, penis or uterus.

5. *Secondary operations for recurrence.*—If the growth reappears in the scar

within a year and extends by infiltration, it is evident that the whole of the primary disease was not removed, and that the disease is of an unfavourable type, for which there is no prospect of relief by further operation.

If a lymphatic gland enlarges after the operation, outside the area covered by removal, a free excision may be in time to arrest the disease.

But a recurrence may appear late, three or more years after the excision, sometimes even as many as thirty years afterwards. Any explanation of late recurrence involves difficulties; cells from the original disease may have remained dormant, just as the cells of a congenital *rest* remain dormant for years, or there may have occurred a recrudescence of the cause which set up the disease in the first place. Broadly speaking, if the disease on its recurrence appears circumscribed and a free removal is anatomically feasible, this should be done; if it appears to be infiltrating widely, only harm will follow from that operation.

6. *The palliative treatment of carcinoma and sarcoma when the primary growth cannot be completely removed.*—In doubtful cases the operation for removal should commence with an exploration of the extent of the disease, and the surgeon should decide that the disease is irremovable before dangerous hæmorrhage or shock has been set up, or an important body cavity involved.

One of the most important palliative measures is the prevention or limitation of septic complications, which is best attained by destroying the primary growth with the diathermic cautery. Pain is infinitely increased by sepsis, and the breaking down of the growth favoured, so that there is more absorption, a greater tendency to hæmorrhage, a more rapid advance of the cancerous cachexia and the earlier death of the patient.

For pain opium in the form of a pill should be given in increasing doses, especially at night, with doses of phenacetin, aspirin, or injections of morphine to relieve exacerbations of pain. Some complications may be relieved by special measures, *e.g.*, vomiting by washing out the stomach and rectal feeding, œsophageal obstruction by gastrostomy, laryngeal obstruction by tracheotomy, intestinal obstruction by colostomy, and strangury by drainage and continuous irrigation of the bladder.

7. *The removal of cancer otherwise than by excision.*—The older practice of attempting to destroy cancer by the actual cautery or caustics was notoriously unsuccessful; it excited the deeper margins of the cancer to more rapid development. The molecular destruction of the disease by new methods has had success in certain cases, but in many merely stimulates the growing parts. Rodent ulcer at an early stage, or small nævi, may be destroyed by X-rays, radium, or zinc ionisation. Several sittings are necessary, and careful observation of the site of the disease for some time afterwards together with prophylactic treatment are required. Such cases, however, can generally be excised at one operation, leaving a linear scar, and the patient immediately assured of cure. Rodent ulcers already too extensive for excision are arrested by the above methods and the site of the ulcer becomes covered by a thin scar, which may remain sound. Unfortunately the disease is often found to be making deep progress in spite of the healing which takes place on the surface.

Some recurrent nodules and ulcerations after the removal of cancer of the breast, or uterus, have yielded to treatment by X-rays or radium in a surprising fashion as if they were instances of feebly developed granulomata. In other cases of recurrences in such scars, matters are made worse by these applications. The insertion of tubes containing radium, or radium emanations, into inoperable cancers has the drawback that pain may be set up.

Special success has followed the use of the diathermic cautery in the treatment of malignant disease of the tonsillar region, the palate and the naso-pharynx ; the results of its application to papillomata of the bladder under the guidance of the cystoscope have been equally encouraging.

The advantages of diathermy may be summarised as follows :—

(1) the extent of its penetration is almost unlimited, whilst at the same time the total amount of dry necrosis set up is strictly under the control of the operator.

(2) Its use is followed by discomfort rather than actual pain.

(3) The resulting inflammatory reaction in the surrounding tissues is very small, and thus there is little or no danger of œdema of the glottis.

(4) Secondary hæmorrhage following its use is extremely rare.

A fungating mass, having first been desiccated, can be removed with the diathermic knife, and the base of the growth thus exposed successfully attacked. In a few weeks the ulcer, formed by the exfoliation of all necrosed tissue, heals and, if the treatment has been carried out thoroughly, leaves a sound scar.

All treatment of cancer by drugs has failed. The only measure of note is Coley's treatment of sarcoma especially as an adjuvant to excision.

Coley's fluid contains toxins derived from the streptococcus of erysipelas mixed with those of bacillus prodigiosus. It is especially in the anomalous, or locally recurring, less malignant types of fibrosarcoma that benefit ensues. The treatment is useless in other conditions, such as carcinoma. Dr. Coley has had many cases of inoperable sarcoma, such cases have been recorded by others also, in which definite improvement or disappearance of the growth followed the treatment. The best results have occurred with doses of an amount sufficient to set up a severe toxæmia lasting about four days, commencing with rigors, a temperature of 102° to 105° F., headache, and profuse sweating. The treatment should begin with the injection daily, or several times a week, of $\frac{1}{2}$ minim diluted with a little water into the tissue around the tumour, and the dose is increased by $\frac{1}{2}$-minims. After a few doses injections are made into the tumour itself, beginning with $\frac{1}{4}$ minim and increasing by $\frac{1}{4}$-minim doses. When the fullest reaction which the patient can bear has been reached, the injections may be made about every tenth day.

## (C.) **Teratomata.**

Under the title of *teratomata* are placed those forms of new growth which consist of various tissues, both connective tissue and epithelial, as if derived from all three layers of the embryo ; of tissues misplaced (*heterotopic*), or untimely (*heterochronic*) as regards the period of development ; of tissue similar to bone, hair, teeth, or that of a dermoid cyst ; of tumours, both solid and cystic, of a mixed structure, similar to that described under *Endothelioma ;* or of various portions of the viscera of a suppressed fœtus or rudimentary twin.

The misplacement of cells, a *heterotopia* or development of tissue abnormal to the part, may be explained as follows :—

(*a*) A cell or group of cells remains undifferentiated, retaining the property of forming both epithelial and connective-tissue elements. Such cell or cells may then go on to form a mixed solid or cystic tumour, a rudimentary or considerably developed monster.

(*b*) Embryonic cells belonging to another part are at an early period included, *e.g.*, cells of the epidermis, in the skin, so as to form a simple dermoid cyst ; but

this is insufficient to explain the complicated dermoid cysts of the ovary. It is assumed that some of these tumours originate from portions of an included embryo.

(*c*) At a later stage tissue may be displaced, as when a meningocele recedes and draws fat and muscle into the spinal canal.

Teratomata are most common in the ovary, in the testis, in the sacro-coccygeal region in connexion, it is presumed, with the canalis neuro-entericus, and also at the upper end of the alimentary canal about the hypophysis, causing polypoid tumours in the naso-pharynx. To this class also belong some abdominal tumours, kidney tumours connected with the Wolffian body and ducts, and mediastinal tumours connected with the thymus.

The ovary may be occupied by a dermoid cyst, the wall of which is comparatively simple in structure, composed of stratified epithelium and dermis, with sebaceous glands, hair-follicles, also subcutaneous fat and sweat-glands. But at points in its wall may also be found cysts and tubes lined with ciliated epithelium, columnar epithelium, thyroid gland tissues (hypoderm), bone and cartilage, muscle, even heart muscle (mesoderm), teeth, brain material, nerves, ganglion cells, mucous glands, choroidal pigment (epiderm). Mixed with this may be carcinomatous tissue, acinous or epitheliomatous, or sarcomatous tissue, with myxomatous degeneration of epithelial tissues to form cysts. Rarer still, these tissues, more confusingly mingled, may compose a solid tumour of the ovary, as if an ovum had developed, but in the utmost disorder, so that the tumour has been called an *embryoma*. Some have seen in this parthenogenesis, the development of an unfertilised ovum, others a fertilised polar body ; more probably an irregular segmentation of an ovum occurs, one half a perfect blastomere, the other imperfect or imperfectly fertilised, yet capable of further irregular segmentation.

Teratomata of the testis are rarely of the complicated character mentioned above, but have been called multilocular cystic tumour, cystic adenoma, chondro-adenoma, chondro-sarcoma, adeno-myo-sarcoma, or simply cystic sarcoma or cystic carcinoma. Some of these tumours may be referred to the endotheliomata, others may be looked upon as new growths connected with the remains of the Wolffian body and the suprarenals.

A more or less developed included fœtus may form an abdominal tumour, partly protrude from the abdominal or thoracic wall, or be loosely attached. Twins are born partly joined, and surgeons have been asked to divide them ; it may be found that the pleural or peritoneal cavities, the livers, the intestinal or urinary systems, are united.

## CYSTS.

A cyst is a sac containing fluid, or semi-fluid, gelatinous or inspissated material. Under this term, cyst or cystic, are collected for practical purposes a number of conditions which defy pathological classification, but having this in common, that one or more cavities exist. The walls of cysts are of very various structure, the contained fluids are totally different in composition. Many cysts are not tumours at all, except in the loose sense of a swelling, but collections of fluid in cavities due to inflammatory causes. Some cysts are merely degenerating tumours, others tumours of new formation.

*Cystic degeneration* is mainly myxomatous or colloid, preceded by œdematous swelling of cells and by fatty degeneration of connective tissue. Dropsical or œdematous swelling of cells is a change in the protoplasm by which serum is taken in. It occurs in inflammation, and is seen in both

epithelial and connective-tissue cells: also in new growths, such as carcinomata, the cell protoplasm and nucleus are distended by vacuoles as a preliminary to the destruction of the cell. The microscopic appearances so produced form pitfalls for the unwary. Fatty degeneration results from diminution of the blood supply, and makes tough and resistant connective-tissue cells yield owing to the distension of the cells with fat globules. The fat globules may collect as oil in dermoid cysts, or crystallise into needles and cholesterin plates. Rupture of blood-vessels and blood extravasation readily occur.

*Myxomatous degeneration.*—Under normal conditions mucus is formed by the goblet cells of mucous membranes, and from the protoplasm of cells in mucous glands, with or without destruction of the cells; also by connective-tissue endothelial cells in the synovial membranes of joints, tendon sheaths, and bursæ. The jelly-like portions of the umbilical cord and the vitreous humour consist of mucus. The substance, mucin, contains nitrogen and sulphur, also a carbo-hydrate forming an animal gum. Nucleo-albumin has similar physical properties, being sticky and semi-fluid. It is obtained from cells largely consisting of nuclei, and is characterised by the amount of phosphorus it contains. In mucous catarrh there is an increased secretion of mucus with a myxomatous change in the pus cells. Epithelial cells in new growths, such as adenomata of the breast, ovarian tumours, and intestinal carcinomata, readily undergo a myxomatous degeneration. By this means a fluid collects containing mucin or an allied substance, such as pseudo-mucin. There is some liability to the giving way of vessels and extravasation of blood as a consequence.

FIG. 23.—A sebaceous cyst divided into halves, and one half emptied of its contents. It is surrounded by a distinct capsule, and is situated in the skin proper superficial to the paniculus adiposus. (St. Bartholomew's Hospital Museum.)

*Hyaline and colloid degeneration.*—The secretion of the thyroid gland is characterised by the formation of a hyaline, semi-translucent, jelly-like substance containing brownish granules. It is an albuminous body, peculiar in containing iodine. A somewhat similar substance forms and dilates the glandular alveoli of new growths. As a further stage the epithelial cells become partly colloidal, partly destroyed in the process. Colloid substances may be seen distending the tubules of the pituitary body, kidney, parovarium, and prostate, and in the tubular strands of the tumours described as endotheliomata. In carcinomata of the stomach, breast, etc., the colloid material gives chemical reactions resembling in some cases those of mucin, in other cases those of an amyloid substance, staining brown with iodine. Hyaline changes in the corneous layers and epithelial cell-nests produce keratin, a substance staining deeply with carmin and fuchsin.

1. **Cysts formed by distension of normally-existing cavities or spaces.**—These are lined by epithelium or endothelium, which may degenerate, and their wall is formed by the condensation of inflammatory fibrous tissue. They have a more or less spherical outline, and are circumscribed and defined from the surrounding tissues, from which they are generally separable with ease. They cause symptoms by the pressure they exert on surrounding structures, or burst and discharge their contents upon a cutaneous, mucous, or serous

surface with or without previous suppuration, or shrink up with fatty or fibrous degeneration and calcification of their walls.

(*a*) *Retention cysts* form in glandular organs or tubes when the main or some of the secondary ducts become blocked. This may be due to inspissation of the secretion, to a calculus, to inflammation or stricture of the wall of the duct, to external pressure on the duct, or to a foreign body impacted in, or pressing on, the duct. Instances of retention cysts are : in the salivary glands obstruction forming a ranula (see Plate 13 B), in the mammary gland a galactocele, in the biliary system distension of the gall-bladder, also a pancreatic cyst, the ureter blocked causing hydronephrosis, encysted hydrocele of the epididymis and a labial cyst from obstruction of a duct of Bartholin's gland. Sebaceous cysts in the skin are common ; they arise on the face and other parts of the skin where sebaceous glands are well marked. A small black point, the obstructed orifice of the sebaceous follicle, may generally be discovered on the surface. From this sebaceous material may be squeezed having the characteristic odour of the armpit. Mucous cysts arise on the lip and in the mouth. Mucous canals may become obstructed and form cysts, as the Fallopian tubes when closed at each end, and the appendix when shut off by inflammation from its connexion with the cæcum. Mucus collects in cavities by closure of the orifices, forming mucoceles, *e.g.*, the maxillary antrum, frontal sinus, lachrymal sac and mastoid cells.

(*b*) *Exudation cysts.*—An excessive secretion or a pathological exudation distends cavities which have no excretory duct. Bursæ become distended, and ganglia arise by a portion of a tendon sheath being shut off by inflammation and distended with fluid.

(*c*) *Extravasation cysts* are due to extravasation of fluids, blood, bile, urine or chyle, into a closed cavity, such as the tunica vaginalis to form a hæmatocele, into the meninges or into portions of the pleura and peritoneum where the fluid becomes enclosed or encysted by inflammatory exudation.

(*d*) *Lymph and chyle cysts.*—Either from an unknown cause in this country, or in consequence of infection in the tropics by filaria sanguinis hominis, the thoracic duct, or some of the lacteals, or one or more of the lymphatics in a limb may become obstructed and give rise to a single or multilocular cyst. These cysts contain lymph or chyle, or the contents may escape on the surface (lymphorrhœa), or into serous cavity (chylous hydrocele).

2. **Congenital cysts.**—A fœtal structure, whether gland or duct, which has not been obliterated may become distended by fluid, or its cells may undergo cystic degeneration; the same may happen to displaced epidermal or endodermal remnants or to an ill-developed normal structure : ducts are imperfectly connected with alveoli, or lymphatic spaces do not communicate freely with lymphatic trunks ; the contents of the cerebro-spinal canal are imperfectly enclosed, resulting in encephaloceles or meningoceles. The distension of the remnant of the Müllerian duct may form a cyst of the hydatid of Morgagni, or a cyst originates from the uterus masculinus behind the bladder ; the remains of the Wolffian body in the parovarium or the ducts of Gærtner give rise to cysts lined with ciliated epithelium. Cysts lined with columnar ciliated epithelium, remaining from the primitive foregut, are found in connexion with the thyro-glossal tract, the trachea, larynx, and œsophagus. The urachus and Meckel's diverticulum, when persisting and shut off from their junction with the bladder or intestine, become dilated. Hydroceles arise in the unobliterated funicular portion of the tunica vaginalis, forming the encysted hydrocele of the spermatic cord in the male, and that of the canal of Nuck in the female.

A dilatation of lymphatic spaces in the neck, axilla, loin or groin gives rise to congenital cystic hygromata. Between the cysts is found fibrous tissue, lymphadenoid, fatty or nævoid tissue.

*Dermoids* are the most striking of the congenital cysts. They occur alone, or in combination with other fœtal remnants, or as part of a teratoma.

*Dermoid cysts of the simpler kind* have a wall composed of the structures forming the skin and its appendages, viz., stratified squamous epithelium, dermis, hair-follicles with hair, sebaceous glands actively secreting their contents, also subcutaneous fat and sweat-glands. They are commonly met with :—(*a*) in the skin of the scalp, or (*b*) attached to the periosteum and quite separate from the skin, above the outer angle of the orbit, (*c*) in the middle line of the floor of the mouth, below the tongue, (*d*) in the lines of the embryonic fissures in the neck, (*e*) in connexion with the thymus, (*f*) in connexion with the ovary in the female, and (*g*) between the bladder and rectum in the male.

The more *complicated dermoid cysts* which merge into the teratomata are especially those connected with the ovary, with the base of the skull around the hypophysis protruding into the naso-pharynx as hairy polypi, and with the spinal column.

The material contained in these cysts is secreted by the sebaceous glands, and has a characteristic odour. It is greyish and porridge-like when stearin prevails in the composition of the fat, or a fluid yellow oil at the temperature of the body when olein is in excess, and the latter is especially found in ovarian dermoids and in those between the bladder and rectum of the male. The oil sets on cooling. Hair may be absent, or, if present, downy like that of the fœtus ; one long hair may be coiled up, a bunch of hairs may project from a prominence into the cyst, or a mass of hairs may be rolled up into a ball. The cyst may burst, and the hairs appear on the surface, *e.g.*, of the bladder, or naso-pharynx.

Dermoid cysts may be noted immediately after birth, especially on the forehead, but are remarkable in often remaining dormant even until quite late in life. Sometimes they have been found under the tongue, quite small at birth, and have remained stationary until puberty. Dermoid cysts on the scalp may not be perceptible until even late in life, and then may keep on appearing. They occur in both men and women, but especially in the females of the same family. If they rupture, the epithelium of the lining wall may grow out to form a horn, or the everted cysts may form a foul fungating ulcer resembling, or actually becoming, an epithelioma. In the ovary dermoids form abdominal tumours, appearing occasionally in children, but generally not until after puberty. Dermoids tend to be multiple on the scalp, and are often bilateral in the ovary.

Dermoid cysts continue to grow and exercise pressure in the abdomen ; under the tongue they hinder swallowing, and in the neck or anterior mediastinum impede respiration. They may burst on the skin, and form a fungous tumour, or the secretion may become inspissated and develop a horn, or the cyst may give rise to a malignant ulcer. They may burst into the urinary or intestinal tract, and hair or oil be passed. A cyst of the ovary may become twisted on its pedicle, undergo gangrene and cause peritonitis, or after becoming tense rupture, and a secondary growth of scattered dermoids follow in the peritoneal cavity. Squamous-celled carcinoma may supervene in the cyst wall, especially when the cyst is in the ovary.

3. **Cysts of new formation.**—(*a*) *Epithelial implantation cysts.*—A fragment of epithelium, also of skin including a hair-follicle, may be carried through a

puncture, into the subcutaneous tissue of a finger or into the anterior chamber of the eyeball. The epithelium may afterwards grow to form a small cyst. A small painless tumour containing epithelial débris may thus appear beneath the scar on the finger, or a hair may grow into the anterior chamber after its implantation upon the iris.

(*b*) *Inflammatory serous cysts* arise by exudation into connective-tissue spaces. The inflammation may be set up by pressure over a bony prominence, and a so-called *adventitious bursa* develop. A foreign body, such as a bullet or needle, may also lie, surrounded by fluid, within a fibrous capsule.

(*c*) *Blood-cysts or hæmatomata.*—A blood-cyst may arise by the dilatation of a varicose vein in the thigh or neck, the communication with the vein either being shut off or persisting, or it may arise by extravasation of blood, around which inflammation goes on to form a fibrous capsule; the serum may be absorbed leaving the dried blood-clot, or the blood-clot may disappear except for hæmatoidin crystals, whilst the serous contents remain. If near the surface, suppuration and abscess may result. Common instances of blood cysts are—the cephal-hæmatomata of the scalp arising during birth or subsequently from injury, cysts in the brain after apoplexy or injury, in the auricle, *hæmatoma auris*, or in muscle as a result of rupture.

4. **Parasitic cysts:** (*a*) **Cysticercus cellulosæ.**—This is the bladder stage of *Tænia solium*, the tape-worm which inhabits the human intestine. The cysticercus forms small spots called "measles" in the flesh of the pig, from which it gains entrance to the human stomach or intestine in imperfectly-cooked flesh. The cysticercus in man is rare in this country. It forms a single spherical swelling, about the size of a marble, in the subcutaneous tissue. Very rarely it is multiple, but when scattered over the skin the condition has been mistaken for molluscum fibrosum. It is also seen in the vitreous chamber of the eye, and in the brain may give rise to epilepsy. The cyst is composed of a white wall containing clear fluid, and the head of a scolex with a rostellum, row of hooklets and suckers; or the cyst may be sterile. Such a cysticercus is due to swallowing eggs of the tape-worm. On reaching the human stomach, where the egg-shells are dissolved, the hooked embryo escapes and bores its way through the stomach wall into the circulation, by which it is carried to a favourable spot for developing into the cystic stage.

(*b*) **Hydatid or echinococcus cysts.**—*Development.*—Hydatid cysts are the bladder stage of the tape-worm, *Tænia echinococcus*, which inhabits the intestines of the dog. Dogs obtain the worms by eating the flesh of cattle diseased by hydatids, the cattle being infected through the ova in dogs' excrement reaching the stomach. The disease is now rare in this country; it was very common in Australia and in Argentina owing to numbers of carcases and offal of diseased cattle being left about for dogs to eat. It is also frequent in Iceland, where, owing to the cold and to the scanty supplies of fuel, the inhabitants for the sake of warmth are accustomed to huddle together with their dogs in single rooms. In this country the history of contact with a dog or the reverse is not of much value as regards diagnosis.

Before the ova from dogs' excrement reach the human stomach, whilst in the proglottides of the parent worm, the embryo has developed six hooklets directed backwards. On reaching the stomach it is hatched, and aided presumably by its hooklets makes its way, either directly towards the liver, or it gains access to a branch of the portal vein, whence it is carried to the liver, or to the lung or into the general circulation as an embolus. It then proceeds to develop into a cyst, but the stages between the hatching of the embryo and the formation of a cyst a month to six weeks later have

FIG. 24.—Diagrams of an echinococcus cycle, arranged after Leukart, Ziegler, and Lendon. 1. The tape-worm, about 6 mm. in length, appearing like chalk-white dots in the duodenum of the dog. 2. An ovum, about 0·01 mm. in diameter, indistinctly showing the six-hooked embryo. 2*a*. The six-hooked embryo free from its shell. 3. An hydatid cyst differentiated into an outer laminated layer surrounding granular parenchyma. 4. The acephalocyst stage. An outer elastic laminated layer and an inner parenchymatous layer of cells and granules, both non-vascular, enclosing fluid. Around the parasitic cyst forms a capsule of fibrous tissue with blood-vessels composing the adventitious cyst. 5. Brood capsules commencing to form in the inner layer when the cyst has reached to about the size of a walnut. 6. A brood capsule showing the development in it from a mass of coarsely granular protoplasm of a scolex or tape-worm head. 7. Daughter cysts forming from the granular protoplasm of the inner layer, and coming to resemble the mother cyst in having an outer laminated and inner parenchymatous layer; one also forming brood capsules. The daughter cysts may bulge inwards and make the mother cyst multilocular, or bulge outwards and make the mother cyst lobulated. 8. Daughter and granddaughter cysts. 9. A grape-like mass of daughter cysts, the mother cyst having disappeared. 10. Shrinkage of the mother cyst causing the parasitic wall to be folded, and between these folds is vascular fibrous tissue belonging to the adventitious cyst, the whole forming a semi-solid or solid mass, having an alveolar honeycomb-like foliated appearance on section, compared to the heart of a cabbage, or resembling a colloid carcinoma. 11 and 11*a*. Scolices or heads of tape-worms, with the rostellum and hooklets protruded or retracted, like a vorticella. They are just visible as specks when the fluid in a glass is held up to the light, and measure in full protrusion about 0·3 mm. 12 and 12*a*. Hooklets, highly magnified.

not yet been traced by experiment. The development takes place most commonly in the liver, in the lung or pleural cavity, in the spleen or somewhere in the subperitoneal tissue of the abdominal cavity, in the brain, subcutaneously, or in the medullary cavity of bone. The wall of the cyst is formed by the parasite, and around this a fibrous inflammatory capsule develops from the patient's tissues. The terms ectocyst and endocyst have been variously applied, by some to the fibrous adventitious capsule and the parasitic cyst wall respectively, by others to the two layers of the parasitic cyst wall itself. The parasitic cyst wall is glistening white, like hard-boiled white of egg, and has about the same consistency. It is divided into an outer elastic *laminated* layer and an inner *parenchymatous* layer of cells and granules. The capsule of vascular fibrous tissue which forms the wall of the adventitious cyst has a variable thickness. The non-vascular parasitic cyst is hardly attached to it at all; thus unlike an encapsuled tumour there is no vascular connexion, the parasite living by diffusion. The parasitic cyst is filled with a clear or slightly opalescent fluid, of very low specific gravity, containing much chloride of sodium, also oxalates and phosphates of lime, traces of sugar when the cyst is in the liver, urea, and crystals of cholesterin, but no albumin; hooklets and scolices may be found in the deposit from the fluid on standing or after centrifugalising. When the parent parasitic cyst has developed to the size of a walnut, or before, small vesicles or brood capsules, seen as opaque spots, form in the parenchymatous inner layer. At a point in the inner wall there collects a mass of coarsely granular protoplasm, which next shows an involution communicating with the cavity of the brood capsule; it is then differentiated into a scolex or tape-worm head, having on its front end a rostellum with a row of hooklets, four suckers, a water vascular system, and refracting bodies composed of lime. The front end may be protruded, or invaginated into the hinder. The cyst may remain simply unilocular, enlarging by increase of fluid and by brood capsules in its wall forming scolices. Or daughter cysts may arise from the granular protoplasm of the inner layer of the mother cyst, which they come to resemble in having an outer laminated and an inner parenchymatous granular wall, from which in turn secondary brood capsules and scolices are developed. The secondary or daughter cysts may fill the mother cyst and cause it to become multilocular, or protrude from the surface, giving the mother cyst a lobulated appearance, or become detached, especially after the rupture of the mother cyst, when they may start an isolated existence, becoming surrounded by a separate fibrous adventitious cyst, and develop in turn tertiary or granddaughter cysts. A mother cyst may not develop brood capsules at all, but remain sterile, without scolices or hooklets, especially within the skull, and is then called an acephalocyst. In the brain or pleura only a very delicate fibrous adventitious capsule develops. In the shaft of bones no adventitious cyst or mother cyst may be found, simply a grape-like mass of daughter cysts, lying freely in the distended cavity.

*Degeneration.*—An hydatid cyst may cease to grow, die, and its contents be converted into a jelly-, putty- or mortar-like mass. Calcification may occur in the fibrous adventitious cyst, or this being thrown into folds and remaining vascular, it intermingles with semi-solid remains of the parasitic cyst to form a tumour, having an alveolar, honeycomb-like or foliated section. In such cases the hooklets remain undestroyed.

*Rupture.*—A cyst may burst spontaneously either before or after suppurating. It may discharge into the peritoneal cavity causing shock and an attack of urticaria, followed by the development of the scattered daughter cysts. But

should suppuration have already begun, virulent fatal peritonitis will be set up. A cyst of the liver, pleura or lung may burst into the respiratory tract, parasitic membrane may be coughed up, and the patient recover, or he may be suffocated at once, or die later from septic absorption. The cyst may also burst:—into the biliary tract and set up acute colic and biliary obstruction; into the intestinal tract; into the pelvis of the kidney causing symptoms of renal colic; into the bladder and produce retention of urine from impaction in the urethra; into the brain or ventricles and cause fatal apoplectic symptoms, or externally through the abdominal wall.

Hydatid cysts may develop singly or be multiple, and may arise simultaneously or at intervals. In the liver, one, two or three distinct cysts may develop. They may recur in the scar following an operation, presumably due to infection at the time.

The *signs* of an hydatid cyst vary with its situation. It generally gives rise to a sensation of a tense globular swelling before degeneration has set in. It may fluctuate if not very tense, and the sensation of percussing a mass of jelly has been deemed peculiar to an hydatid cyst and called *hydatid thrill* or *fremitus*, but this is not a necessary sign. A relative absence of symptoms may aid in the formation of a diagnosis by exclusion, *e.g.*, in the case of a liver tumour. Eosinophilia characterises the presence of almost every vermiform parasite, and is very constant when the cyst is situated in the liver and the parasites alive.

*Prevention.*—Inspection of meat and its destruction when found infected, including the entrails, will prevent dogs from devouring hydatids. A dog may be rid of the worms by anthelmintics. Cleanliness in its kennel and the destruction of its excrement will prevent ova or proglottides from being swallowed by cattle.

*Distribution of hydatids.*—The percentage occurrence of hydatids among 1,900 cases was found to be: Liver 57, lung 11·6, brain 4·7, spleen 2·1, heart 1·8, peritoneum, omentum and mesentery 1·4, muscles 7, female organs and breast 4, true pelvis 3, spleen and bones 3, vessels 2.

*Hydatids* of the *liver*, *lungs*, *brain* and *bones* will be described under those heads.

Among the *rarer forms* may be noticed hydatids compressing the spinal cord, or growing in the orbit and displacing the eye, or in the thyroid gland, three of the latter out of six cases proving fatal from perforation of the trachea. A cyst of the female breast has proved to be an hydatid. In the abdomen, besides the connexion with the liver, the spleen may be affected, a cyst may be attached to the omentum or mesentery, or after rupture the whole peritoneal cavity may be sown with cysts. A cyst is likely to settle down and develop in the rectovesical pouch of the male, and in Douglas's pouch in the female, or may pass into the scrotum through a patent funicular process. Alternatively they may arise in the connective tissue beneath the peritoneum, and so, for instance, become attached to the ovary. Hydatids discharging through the uterus require to be distinguished from an hydatidiform mole. Hydatids may develop at the site of an injury whether the injury be a subcutaneous hæmatoma or fracture, or an open wound, including one due to gunshot.

**General treatment of cysts.**—Wherever possible a cyst should be removed completely, either by shelling it out or dissecting it away from the surrounding structures, or by tying the pedicle if there is one. This is especially the case with all epithelial cysts, whether retention-cysts or those of new formation, any remains of the wall being able to cause the cyst to re-form. In some cases

in which, as in the salivary gland, bile duct, or ureter, the retention is due to some removable cause such as a calculus, it may be sufficient to deal with this. A fibrous cyst, although not lined with epithelium, should generally be dissected away, especially if the wall is composed of new growth or of thick inflammatory tissue, such as a bursa. If this cannot be done, the contents should be completely evacuated through a free incision, and the cavity filled with gauze, which is renewed at each dressing until healing occurs. Only rarely can a cyst with a thin wall and serous contents be evacuated and sutured, nor is a drainage tube so good as gauze, for fluid is apt to remain in the cavity and decompose. An hydatid parasitic cyst is completely shelled out from the adventitious cyst when vascular, as in the case of the liver, or near important structures such as the brain, great care being taken to remove the whole of the parasitic membrane without setting up hæmorrhage from the wall of the adventitious cyst. Degenerated and small hydatid cysts are to be dissected out, adventitious cyst and all, whenever this can be done.

Aspiration for diagnosis must be immediately followed by evacuation. It is not to be considered a method of treatment. It has been very rarely successful even with a thin yielding wall and serous contents. Tapping hydatid cysts is a much more dangerous method than incision, quite apart from the question of cure. Injection with iodine should never be employed ; it is not only useless, but dangerous. Even in cases of thin-walled lymph cysts, meningoceles, etc., excision is the right procedure.

# Section II.

## GENERAL SURGERY.

### Wounds.

A WOUND is a forcible solution of continuity of the tissues. Wounds may be (A) closed (subcutaneous or submucous) or (B) open. In the latter, skin or mucous membrane is involved, whereas in the former, they remain intact.

(A) **Closed wounds (subcutaneous or submucous).**—Wounds belonging to this class are spoken of as *bruises* or *contusions*, and result from external violence which does not cause a tear of the skin or mucous membrane. The most obvious external evidence of such a lesion is a swelling, resulting from the extravasation of blood from torn blood-vessels, which will vary in size, depending on the calibre of the vessel which has been damaged; other factors also play a part in the degree of the swelling, *e.g.*, the looseness of the tissues, the presence of some diathesis such as hæmophilia, etc.

An *ecchymosis* belongs to this class, and is the slightest degree of contusion resulting from the rupture of small vessels just under the skin. A bruise may be evidence of a deep hæmorrhage which has tracked along the connective tissue planes, usually towards some dependent point of the skin; if it appears within a short period of the injury, the vessels torn are close to the surface, whereas if it appears three or four days later the blood effusion has extended from the depths. When large vessels are torn in the limbs the degree of bleeding may be very considerable and may cause the limb to swell to twice its original size. This swelling may extend for a great distance in a longitudinal direction from the point of injury. In some cases bullæ appear on the skin surface.

*Results after contusions.*—1. *Resolution.*—The stained areas on the surface change in colour from purple to black, green, yellow, and then gradually fade, as the result of changes taking place in the hæmoglobin.

2. *Localisation of hæmorrhage.*—A localised collection of blood is called a *hæmatoma* and is recognised as a fluctuating swelling with a more or less definite outline, situated as a rule under the site of the injury. Various changes may take place in it:—

(*a*) It may become completely absorbed.

(*b*) It may clot, the serum being absorbed and the fibrin becoming converted into a fibrous nodule.

(*c*) It may remain as a blood-cyst.

(*d*) It may suppurate.

3. *Suppuration.*—In a limb the extravasated blood may suppurate from infection of the devitalised tissues through the blood-stream. If the hæmorrhage is in the neighbourhood of such structures as the bowel or the mouth, it may become infected by direct contact.

4. *Gangrene* of the tissues, especially in the case of a limb, may arise from pressure on a main blood-vessel by a large extravasation of blood. It may also result from the actual devitalisation of the tissues involved in the injury.

*Treatment.*—The injured parts must be placed at rest, the degree of

damage having been accurately ascertained. Bullæ are punctured to allow the serum to escape and are kept dry. Cold packs and evaporating lotions should be applied to the part, which, in the case of a limb, should be raised. Except in the case of rupture of main blood-vessels, the bleeding stops spontaneously by pressure of the extravasated blood on the damaged vessel, and no further surgical procedures are called for. It may be necessary to relieve the patient's pain by the use of drugs and in some cases to deal with shock.

As soon as it is obvious that hæmorrhage has stopped (except when due to hæmophilia), massage should be commenced.

A hæmatoma is usually absorbed, but if large it may be aspirated or incised, blood-clot cleared out, and the incision closed. If a blood-cyst remains it should be excised.

Suppuration should be dealt with as in other suppurative conditions.

(B) **Open wounds** may be sub-divided into :—

(*a*) *Incised wounds* have clean-cut edges, with little or no bruising of the surrounding tissues. They result most commonly from an injury with a sharp instrument, such as is produced by the surgeon's knife in the course of an operation, by injury with glass, etc. They bleed freely.

(*b*) *Lacerated wounds* are produced by tearing of the tissues by some rough instrument, *e.g.*, tear of a nail, in machinery and street accidents, by the bites of animals, and by pieces of shell, etc. The tear is usually irregular, and the surrounding tissues are damaged, but there is seldom any serious hæmorrhage, as the smaller vessels are torn across in an irregular fashion, which leads to early clotting.

(*c*) *Punctured or penetrating wounds* are those in which the depth of the wound is much greater than the breadth, and result from injury by sharp-pointed instruments, *e.g.*, bayonets, swords, rifle bullets, etc. The deeper tissues are involved in these cases, and there is liable to be considerable hæmorrhage into and between them.

(*d*) *Contused wounds* are those in which, in addition to a break in the skin surface, considerable damage is done both to the skin and underlying tissues, to such an extent as even to devitalise them completely. They are most commonly produced by injury with heavy weights.

(*e*) *Abrasion* means a mere surface loss of tissue, such as may be produced by a glancing blow.

(*f*) *Gunshot wounds.*

The complications of open wounds are numerous. The first is *hæmorrhage*, which may either take place through the wound or into the damaged subcutaneous and submucous tissues. As a rule, the sharper the instrument causing the injury the more severe is the hæmorrhage, owing to the cleaner cutting of the blood-vessels. Secondly, *infection*. As hæmorrhage requires the primary attention of the surgeon after tissues have been injured, so does infection cause his second anxiety. The main object of treatment of all open wounds is to prevent infection taking place in them, and should it occur, to deal with it. Thirdly, *important structures may have become damaged*, *e.g.*, nerves, large blood-vessels, tendons, etc. ; in every case of an open wound such complications must be sought for.

*Treatment of open wounds.*—The ideal surgical treatment of wounds is to prevent them from becoming infected. Bacteria obtain their entrance into a wound at the time of the injury and for a certain period lie loose among the tissues without harmful effect; such a wound is said to have become contaminated. Under adverse conditions and in the absence of adequate treatment these bacteria obtain an entrance into and damage the living

tissues; this is infection. Contamination takes place at the time of the injury, and thus the majority of wounds are liable to become infected: this is true of all types of open wounds with the exception of the incised wound made by a surgeon, with properly prepared instruments, on a properly prepared patient; that is to say, where the conditions are such as to provide a minimum opportunity for bacteria to obtain an entrance into the wound. When it is probable or is known that contamination of the wound has occurred at the time of injury, owing to its production by a non-sterile implement, it must be treated as an infected wound. It is obvious that one of two courses of procedure is called for: (1) for a non-infected wound, and (2) for an infected wound.

*Treatment of non-infected wound.*—This applies to the incised wound made by the surgeon in performing an operation. The object of the treatment is to *prevent* contamination and thus avoid infection. Two systems are possible: (1) the antiseptic system; (2) the aseptic system. Antiseptic treatment aims at the destruction of bacteria by the use of drugs known to have bactericidal properties. These drugs are relied on for the sterilisation of all agents which may be the source of infection, including the wound itself, instruments, air, dressings, towels, gowns, etc. The aseptic system uses no chemicals during the course of the treatment, but relies on heat for the sterilisation of all instruments and materials which come in contact with the wound, and assumes that these are so prepared as to make the introduction of bacteria impossible, thus avoiding the necessity of the use of antiseptics in the wound.

The great objection to the antiseptic method is that, if a drug is sufficiently powerful to kill bacteria in a wound, it will damage the tissues and lead to harmful results, even causing suppuration; moreover, if bacteria have not been introduced, its use is unnecessary. It is not possible to be strictly aseptic, for, in order to render the patient's skin free from infection, chemicals must be used. With this exception, however, aseptic methods are those which should be practised in the case of a non-infected wound. Aseptic surgery is also used in dealing with an infected wound so far as the preparation of instruments, gowns, etc., is concerned, although antiseptics may be applied to the wound itself. In considering aseptic surgery it is necessary to recognise the possible sources of infection and to discuss the various preparations necessary to avoid possible contamination with bacteria. They will be discussed under the following headings:—

1. Preparation of patient.
2. Preparation of surgeon, his assistants and nurses.
3. Preparation of operation room.
4. Preparation of instruments.
5. Lotions to be used.
6. Ligatures, sutures, etc.
7. Details of the operation.
8. Drainage.
9. Dressings.
10. Bandages.
11. Patient's room.
12. After-treatment.

1. **Preparation of the patient.**—The main principle to be observed in the preparation of the patient is to prevent infection of the wound and secure as speedy a recovery as possible with the least discomfort. The instructions detailed should be carried out as far as the urgency of the operation will allow.

(*a*) *General preparation.*—It is presumed that a full examination of the patient has been made in order to ascertain his fitness for the particular operation about to be performed. This should, of course, include an examination of the condition of his heart, lungs, bowels, urine, etc., in addition to the local condition for which the operation is demanded; the presence of some wasting disease, nephritis, or an infective focus somewhere else, etc., predisposes to wound infection. It is advisable to keep the patient in bed for at least twenty-four hours prior to the operation; in some cases a longer period is necessary. Care is taken that a patient sleeps well the night prior to an extensive operation; this aims at raising the patient's resistance to the highest point. An efficient aperient should be given overnight, to be followed by a soap or soap and oil enema in the early morning; this may be required for several days before operating upon certain abdominal conditions, and others, such as the operation for a radical cure of piles. During these twenty-four hours the amount of food taken should be limited, but no period of starvation is necessary, provided that an interval of at least four hours elapses from the last meal; for this reason the early morning is a convenient time at which to perform an operation. On waking, some hot soup, tea, cocoa, coffee, milk, or water may be given, but not in such large amounts as are likely to cause vomiting after the operation; it is especially important, in children, that they should not be starved for a prolonged period. In the case of an emergency operation it is not always possible to take these precautions; an enema, however, can always be given, and, if need be (*e.g.*, in some gastric cases), the stomach can be washed out. The patient must always be reminded to pass water just before the operation commences, and if on account of nervousness he cannot do so, a catheter should be passed; this should be a routine measure in all pelvic cases; in women with a tumour wedged in the pelvis, the urethra is likely to be obstructed.

(*b*) *Local preparation.*—(i.) *The skin.*—With regard to the personal cleanliness of the patient, some surgeons still carry out an elaborate overnight preparation of the region to be operated on; this is, as a rule, quite unnecessary. The patient should be given a bath a few hours before the operation, or failing this, on account of the nature of the illness, he should be washed, with the free use of soap and water, and a change of bed-clothing given; all hair should be removed from the neighbourhood by shaving. It is a good general principle that as large an area as possible should receive these attentions rather than one which is too small; for example, in all abdominal operations the whole of the abdomen should be prepared; in all intra-cranial operations, the whole scalp should be shaved; in all operations on the limbs, the whole of the circumference should be dealt with. This, as a rule, is all that is called for prior to the appearance of the patient on the operation table; but it is sometimes desirable to apply preliminary antiseptic dressings on the previous night in cases in which ordinary bodily cleanliness is not customarily observed. If there is any difficulty in removing dirt, special care must be taken; the use of a scrubbing brush and soap and water will go a long way, but ether, turpentine, or spirit will get rid of collections of débris and fat which cannot be so removed. Crusts of dirt and sweat may require the application of fomentations and hot baths; if such are demanded, the operation must be delayed until any abrasions which may be produced are healed. It must be remembered that excessive preparation of the skin may, by damaging the tissues, predispose to infection.

(ii.) *The mouth.*—As a preliminary measure to operative procedures in the mouth, the teeth should receive attention; all necrosed teeth should

be removed; as far as possible tartar should be scraped off, and in some conditions all the teeth may require to be extracted. Preliminary mouth-washes should be used for some days; the best of these are potassium permanganate, and hydrogen peroxide (see, further, *Oral Sepsis*).

(iii.) *The rectum.*—As mentioned above, this requires special attention, with the use of purgatives. For at least three days prior to the operation the bowels should be freely opened. On the night before the operation a saline wash-out should be given, and a similar procedure carried out after the use of an enema on the following morning. It should be the care of the nurse to see that the rectum is empty prior to the appearance of the patient on the operation table.

(iv.) *The vagina.*—Preliminary wash-outs should be given to the vagina in the case of all operative measures on the pelvic organs in the female.

(v.) *The urethra and bladder.*—Preliminary wash-outs should be given to the bladder and urethra in all operative measures to be carried out in these regions.

(vi.) *Special preparation required before the administration of the anæsthetic.*—Many of the processes mentioned above are designed to diminish the effects of the anæsthetic. Special care should be taken to see that a patient having artificial teeth should remove them. In the case of some anæsthetists, preliminary injections of morphin, atropin, and scopolamin are asked for, especially if gas and oxygen, or local anæsthesia, is to be used. The anæsthetist should be consulted on this matter before the operation is performed, as the injections require to be given at least an hour before it takes place.

2. **Preparation of surgeon and nurses.**—At all operations the surgeon requires an assistant besides the anæsthetist. In some of the larger operations more than one assistant may be necessary. At least two nurses should be available; it is inadvisable that more than three should be present; each nurse should have her duties allotted to her prior to the operation, so as to avoid confusion and thus increase efficiency. The remarks which follow with regard to the preparation necessary apply to all those assisting at the operation.

(*a*) *The hands.*—The first attention should be paid to the hands; it must become a habit of all those associated with aseptic surgical procedures that their hands should be always clean from frequent washing, paring and trimming of nails, and the removal of all loose tags of skin. The fact that gloves are to be worn should in no way be allowed to diminish the care bestowed on the hands. Preliminary to the operation itself, the hands should be well washed by the free use of soap and hot water and a scrubbing brush, the skin being so treated as high as the elbows. If dirt is collected in cracks, etc., ether soap should be used. (Some surgeons then immerse their hands in a 1—500 alcoholic solution of biniodide of mercury or plain methylated spirit for at least two minutes.) Even after this preparation the staphylococcus albus can be isolated from the skin, but, being a comparatively harmless micro-organism, is not liable to cause infection in a wound, as experience has shown. After the hands have been so cleansed, nothing must be touched by them except those things which have been sterilised for the purpose of the operation; if this is done, the process must be repeated. Likewise in the performance of routine dressings in the wards, especially when dealing with septic cases, the fingers should be used as little as possible, their place being taken by forceps, which should be employed to remove and replace the dressings. It is obvious that, if pathological material has been handled prior to the performance of an operation, special care must be taken.

(*b*) *The clothing.*—Prior to entering a theatre all those taking part in or intending to witness the operation should wear goloshes or some other suitable covering to the boots, for the protection of the floor, which otherwise would become contaminated with dirt from the outside. The surgeon, assistant, nurses, etc., present in the theatre must all be clothed in sterile gowns so as to cover completely the clothing, and especially the arms down to the wrist joints. The surgeon and his assistant should wear sterilised mackintosh aprons under their gowns, so that if the latter get wet their clothes will not get soiled. The hair should be covered with some form of cap, and if a beard is worn some covering is necessary to prevent particles detached by contact of the hair with the chest from falling into the wound. Some surgeons insist on the use of a mask to cover the nose and mouth. This is essential when those performing the operation have any chronic infective condition in the nose and mouth, *e.g.*, suppuration in the antrum of Highmore, pyorrhœa alveolaris, etc., or even during periods of acute and sub-acute nasal or pharyngeal catarrh; it is not so essential, however, when the condition of the mouth and nose is normal. The epidemics of suppuration occurring in the practice of a surgeon are usually found to be due to a lack of these precautions. The hands of all those taking part in the operation must be covered with sterilised rubber gloves, which should be drawn up over the lower end of the sleeve of the gown.

3. **Preparation of the room.**—(*a*) *In a hospital.*—The operation theatre should consist of a suite of rooms, *e.g.*, the theatre, anæsthetising room, sterilising room, surgeons', nurses', and students' preparation rooms, recovery room, and, in the best establishments, a pathological and X-ray room are also provided. If there is more than one theatre, some of these rooms may be common to both. Operation theatres are built and furnished with the object of preventing any chance infection during the operation. The floors, walls, and ceilings are covered with materials which can be readily and frequently washed, the corners being rounded off so as to avoid crannies in which dirt may collect. There should not be any ornamental accessories in the theatre. Provision should also be made for the efficient heating of the room, so that a temperature of 65—70° F. or even higher may be maintained, with a frequent change of air; special forms of ventilation, with warm filtered air, are used. All drains must be well trapped. The lighting requires special attention; if possible, a north light should be used; artificial lighting by electricity should be so arranged as to avoid the casting of shadows; additional lights for special purposes should also be available, *e.g.*, head-lights, hand-lamps, etc. The holders of the movable lighting apparatus should be as simply constructed as possible and provided with sterilised coverings, so that they may be held by the surgeon if he desires. An electric current with transformer fixed to the wall should also be available for lighting cystoscopes, sigmoidoscopes, etc., at the same time adjustable for the use of the cautery. Sinks for separate purposes should be fixed to the walls—one for hand washing, one for washing bowls, and a third for throwing away dirty lotions, etc. The tables consist of one on which to operate, which may be of a variety of patterns, but should be fixed on a firm base with adaptations for special purposes, *e.g.*, lithotomy, elevation of pelvis, Trendelenburg's position, etc. Another table must be available for the instruments, ligatures, etc., and a third for dressings, swabs, etc., and yet another for the anæsthetist. It is desirable that as little furniture as possible should be placed in the theatres, but the above are essential.

(*b*) *Operations in private* do perfectly well when the house is satisfactory

from a general sanitary point of view. If time admits the room is prepared by clearing it entirely of furniture, hangings, and pictures; scrubbing the floor and doors and windows; and seeing that the latter fit for opening and closing properly, that the chimney does not smoke, and that no drains or sinks open near. The room should be opened to fresh air and sunlight for a day or so. Then the heating and ventilation are adjusted so that the temperature can be kept day and night at about 65° F., and there should be for the patient at least 1,500 cubic feet of air space, and so ventilated that the air can be changed at least every hour. For the operation a strong, narrow table should be placed near the window and covered with several layers of blanket and a mackintosh to protect the patient from bruising and pressure, *e.g.*, on the musculo-spiral nerve. Three or four occasional tables are covered with sterilised towels. Meat or pie dishes, basins, large and small, and jugs, several of each, are collected, scrubbed with soap and hot soda-water, scalded out with boiling water, or boiled for twenty minutes in a copper or clean fish-kettle, or rinsed with 1 in 20 carbolic acid and then covered by towels to protect them from dust. Several gallons of water are prepared by boiling for half an hour, and, if it has to stand some hours, boric acid is added. A dozen or two of clean towels are obtained, and some are sterilised as mentioned below. A narrow bed is prepared with a firm, smooth horsehair mattress. Under the patient is laid a mackintosh sheet covered by another of linen. A blanket is made hot before the fire ready to wrap the patient in after the operation; also hot-water bottles must be filled by the time the operation is ended and put into the bed, but must be separated by a blanket from the patient, or a troublesome burn may easily be caused in a weak subject during unconsciousness.

(*c*) *An urgent operation* has often to be done under unfavourable circumstances; it is well in such a case to disturb dust and dirt as little as possible by operating in the middle of the room and leaving pictures and furniture undisturbed, whilst sprinkling water or spreading a damped sheet over the floor to lay the dust. In operating at night, common glass lamps are most dangerous. Several candles stuck in suitable positions to avoid shadows, motor-car lamps, or a portable electric light prove serviceable. Inflammable material used in surgery, loose cotton wool, benzine, ether, spirit, collodion and celluloid material should always be kept away from a naked light; a gas fire should be turned out just before commencing the anæsthetic when in a small room, for with chloroform vapour phosgene gas may be produced and ether vapour may become ignited.

4. **Preparation of instruments.**—Before every operation instruments, gloves, etc., should be properly sterilised.

(*a*) *The instruments.*—All instruments used at an operation, with the exception of those having sharp edges, should be boiled in soda solution for thirty minutes; the soda, in small quantity, is added to prevent the rusting of the instruments and also to raise the temperature of the water. The knives, saws, and needles should not be so treated, otherwise the edge and temper will soon be lost; they should be placed in methylated spirit for thirty minutes and then washed in sterile water just before use. A better method still, but one not easily applicable, is sterilisation by dry heat. When the instruments are ready for use they should be placed in a tray on a dry sterile towel, which should be large enough to fold back as a covering over the top of the instruments until they are actually required. Some surgeons prefer to have their instruments immersed in sterile water or saline solution. After the operation all instruments should be scrubbed free of blood, washed in cold

water, and again boiled for thirty minutes in a 1 per cent. solution of washing soda, and, prior to their being placed in the storage cupboard, should be wiped over with spirit, dried, and polished.

(*b*) *Gloves* may be prepared by one of two methods: either by boiling in water, to which soda has *not* been added, for half an hour, care being taken to see that they are filled with water before their immersion in the steriliser, otherwise they will become damaged; or by sterilising in a high-pressure steriliser at 230° F., and used dry. In the case of those prepared by water sterilisation, they can be easily slipped over the hands by filling them with water or by previous immersion of the hands in a bowl of spirit solution, or by lubrication with ether soap or glycerin. If used dry, a sterilised talc powder serves the same purpose. Care must be taken after their use that the gloves are washed both inside and outside, sterilised in boiling water, and then dried; an examination should be made of each, either by filling with water or by distending with air, to see that there are no holes in the fingers, caused by pricking during the operation. Such gloves should either be discarded or some efficient method of reparation used.

(*c*) *Towels, gowns, masks, swabs, plugging, mops, and pads for sponging or packing.*—Swabs, etc., are made of layers of plain gauze or lint; they may be of any size and should be placed in known numbers in gauze bags or tied together in bundles; these, including gowns, towels, masks, dressings, and bandages, are loosely packed in a drum, which should have perforated walls. The packing of these drums, which should not be too tight, must be done in layers from bottom to top, so that the several articles can be taken out in the order in which they are required at the operation. The drum is then placed in the steam steriliser with the perforations in the drum open so as to allow the steam to penetrate into the dressings; the lid of the steriliser is clamped down and the heat, to a temperature of 250° F., applied for half an hour. The top of the steriliser is then raised for a quarter of an hour to allow the steam to escape (or the steam may be sucked off into pipes), lest it should condense and make everything wet; the perforations in the drum are then closed, thus sealing it till it is required. The materials should be picked out of the vessel with sterilised forceps. The apparatus requires to be tested from time to time by submitting the contents of the drum to bacteriological investigation.

(*d*) *Marine sponges* are occasionally employed in operations on the throat and bladder, etc., but owing to the difficulty in preparing and cleaning them they are not in general use. They must first be freed from sand and remains of marine organisms by prolonged soaking and kneading in water; this is followed by soaking in hydrochloric acid (1 in 10) for twelve hours, and then salinated soda solution for a similar period; they are then covered for twelve hours with sulphurous acid, 20 per cent. Between each of these processes the sponges should be well washed in running water for half an hour. After all acid has been washed away, the sponges are placed in a jar containing 1 in 20 carbolic acid, where they remain at least two days before use. They may be so preserved indefinitely, merely becoming browner, or the sponges may be counted into linen bags, which are tied, labelled, and then hung up to dry in the air. Prior to their use they are steeped in sterile water; after use they should be soaked in soda solution for a day or two until all the fibrin of the blood has become dissolved. When the water in which the sponges have been soaked remains clear they are again treated as above described, with the exception that a period of twenty-four hours is substituted for twelve.

(*e*) *Syringes.*—Those syringes which are of most service are made of metal, and should be treated as other instruments. Syringes used for aspirating purposes and having needles should have the latter treated by immersion in spirit, which should be run through the hollow of the needle several times before it is used. Great care should be taken to remove any foreign material which may be contained in the lumen of the needle after it has been used, by the passage of a wire obturator.

(*f*) *Catheters*, after use and before drying, should be syringed through with soap and water to get rid of oil and mucus; this should be followed by boiled water. Metal catheters are sterilised by boiling in the usual way. Rubber, silk-web and gum-elastic catheters may be similarly treated by immersion in boiling water for a few minutes, if there is no question of expense, but good results can be obtained by placing them in a metal cupboard provided with suitable trays through which formalin vapour can be passed; they should be left in such an apparatus for at least twelve hours. Care should be taken in opening the chamber to see that the vapour can escape into the open air, as it is most irritating to the mucous membranes. Failing this method, they are sterilised by complete immersion for half an hour in a solution of mercury biniodide (1 in 1,000) or some similar antiseptic. Prior to its passage into the urethra the catheter should be immersed and washed through in sterile water.

5. **Lotions to be used.**—The only lotions required in a purely aseptic operation are plain sterile water or normal saline solution. This should be placed in china or enamel-lined bowls, which have been previously sterilised by heat or boiling, for the use of the surgeon, his assistant, and the nurses during the operation. Some means of storing the solution must be provided for by a specially-arranged tap in the operating theatre, or jugs treated in similar manner to the bowls; for these suitable coverings should be supplied. The source of the supply must be in some position handy to the operation table, as the lotion should be repeatedly changed as soon as it becomes contaminated with blood from the wound. There should be a large number of these bowls, but fair efficiency can be obtained with a few by swilling out the contents with clean water, the dirty water being thrown away. In a private house the various utensils used for this purpose can be either scalded out with boiling water or "burned" out by lighting a small quantity of methylated spirit inside the bowl or jug and allowing the flame to die out. This water is used to soak the pads in when it is required to swab out blood from the wound, also to wash off blood from the surgeon's hands.

6. **Ligatures and sutures, etc.**—Ligatures are used for the tying of blood-vessels which have been cut across; sutures for the sewing up of the wound. Some materials serve both purposes. The various materials in use are silk, thread, catgut, silkworm gut, wire and horsehair.

(*a*) Closely-twisted or plaited silk in various sizes, or linen thread, serve all purposes. These variations in size are necessitated by the different uses to which the material is to be put, *e.g.*, the thinner for suturing the intestinal wall, the thicker for tying the large blood-vessels or intra-abdominal pedicles. The silk or thread is wound loosely on a leaden or glass reel in a suitable quantity for an operation, and is sterilised by boiling in plain water for thirty minutes. The free end of the material should be so situated in relation to the reel that it can be easily found. Floss silk can be used for large pedicles. These materials do not become absorbed by the tissues, and may become the source of much trouble if the wound suppurates, for, until they are discharged, a sinus, known as a *stitch sinus*, will remain.

(*b*) Catgut is prepared by allowing sheep's intestines to rot, then twisting up the remainder, which consists mainly of the submucous and fibrous tissues. In this way many virulent micro-organisms are included which must be destroyed. Innumerable methods of disinfection have been brought forward, but few of them are satisfactory with the exception of the proprietary chromicised preparations, many of which are on the market, the commonest being *van Horn's*. This material is especially useful in situations in which it is desired that the ligature material should be absorbed, *e.g.*, in the urinary tract. For this purpose catgut, which is absorbed by the living tissues, is prepared in such a way as to last a given number of days.

(*c*) Silkworm or fishing gut is composed of unspun silk, and is sterilised by boiling in water for thirty minutes. The strands are excellent for interrupted sutures in the skin or muscular tissues, but they are useless for tying blood-vessels owing to their rigidity. This is a non-absorbable form of suture.

(*d*) Wires of various forms are of great service under certain conditions, especially in suturing the ends of bones. Silver, bronze, and aluminium are the three metals most commonly in use. They have been used in the form of a framework or filigree in the abdominal wall in cases of hernia. Metal, however, is likely to cause trouble by irritation, and frequently has to be removed at some time remote from the operation.

(*e*) Horsehair, which is now little used, should not be boiled for more than five minutes, as it becomes very brittle. It is used for suturing purposes.

7. **Details of the operation.**—The patient is anæsthetised before being placed on the operation table and is well covered up, except for the part to be operated upon, as a protection from loss of heat; mackintosh coverings should be used in such a way as to avoid the patient getting wet. The legs and feet are covered with stockings; babies are swathed in wool. In some countries the patient is stripped, placed on a heated table, and the temperature of the room kept up to 80° F., but the heat is most oppressive, and other objections to such measures are obvious. In civilian practice it is seldom necessary to heat the table. Care must be taken to see that the upper arm does not hang over the side of the table, otherwise pressure palsies, especially involving the musculo-spinal nerve, may be produced. Similar care should be taken to see that the feet do not hang over the end and rest against the sharp edge of the table. Hot-water bottles, which may be required near to the patient in cases of severe shock, must not be allowed to touch the skin, otherwise burns are liable to be produced.

The posture of the patient depends to a great extent on the type of operation which is about to be performed; usually he is placed in the *dorsal* position, the legs fully extended, with his arms down to his side and the extended hands fixed underneath the buttocks. The *lateral* position is also a common one; the arm of the side on which the patient is lying is drawn through to the back, the lower leg is fully flexed on to the abdomen, and a sandbag is placed under the knee; the arm on the side to be operated on is fixed on a rest, the corresponding leg being fully extended; in this way the patient is kept in a stable position. The *lateral prone* position is employed by many for operations on the mouth and throat, so that the blood and mucus can easily escape by the mouth at the lower angle. The *sitting or partly reclining* posture is chiefly employed by dental surgeons. The *completely prone* position, the shoulders and head being partly supported by pillows, is a difficult one for the anæsthetist; it is employed for operations on the spine and loins, with the legs hanging down for operations on the rectum and buttocks. The *lithotomy* position, with the patient lying flat on his back

and the legs held so that the thighs make a right angle with the table, is used for perineal operations, and the *Trendelenburg* position, which is that in which the patient's body is inclined with the head lowermost, is used for pelvic operations; the patient is prevented from slipping by special shoulder supports attached to the operation table, and the legs are then allowed to hang down over the lower end. A number of other positions may be used, but the above are those most commonly adopted. The posture of the patient should receive the first attention.

The operation area is then isolated by mackintosh sheets, kept in position by pins or clips. The area to be operated upon is washed over with ether or acetone, to be followed by painting with alcoholic iodine (2½ per cent.) or picric acid solution (3 per cent.). When the latter has evaporated, sterilised towels should be placed over the mackintosh sheets. This preparation is all that is required, provided that the instructions mentioned above have been carried out as a preliminary measure.

All swabs and instruments must first be counted and the number put down on a slate; this observance is especially essential in all operations on the abdomen. Care must be taken not to cut any swabs into two during the operation, for fear of making mistakes when they are counted at the end. All objects handed to the surgeon by assistants and nurses should, as far as possible, be held on sterilised forceps and towels.

*General course of the operation.*—The surgeon must be fully cognisant of the surgical anatomy of the part on which he proposes to operate, and he should have a plan in his mind as to how he intends to carry out the procedure. He then places himself and his assistant in positions most convenient for the performance of the operation; the instruments should be ready to his hand and also the table supporting the swabs, with its attendant nurse. In addition to ordinary good light, natural or artificial, in some deep wounds special illumination is needed, by means of a head-lamp or light reflected by a head-mirror. The operator then selects a knife, and, holding it in his right hand as a violin bow, dinner knife, or pen, he points it almost vertically downwards and punctures the skin; the handle is then sloped and a steady cut made through the skin for the required distance, the incision being completed with the knife held almost vertically. The major part of the incision should be made with the belly of the knife, and not its point; this procedure is aided by keeping the skin a little tense between the finger and thumb of the left hand. The edges of the skin are then protected by tetraclothes, which should be of sufficient size to cover up the rest of the exposed skin area and attached over the skin edges by special clips, so that, when complete, no portion of the skin, including its edge, can be seen. This prevents infection of the rest of the wound by bacteria which normally live in the skin, *e.g.*, staphylococcus albus. The clips which attach the clothes to the skin also serve as retractors. During no part of the operation should the fingers be placed in the wound; all manipulations should be carried out by means of dissecting forceps. Aponeuroses and muscles should be split, as far as possible, in the axes of their fibres. Under some conditions it may be necessary to cut across them, but as this obviously weakens the tissues it should be avoided as far as possible.

Vessels which bleed, or which can be seen in the line of the incision prior to their division, are seized with clamp forceps, which should be of small size, and allowed to hang over the edges of the wound until the exposure required is finished, when ligatures are applied over the forceps. The greatest care must be taken in these manipulations not to damage the tissues or to bruise

them. The wound should be sponged as little as possible, dry swabs being used. Water or saline should only be run into the wound when it is necessary to get rid of blood clot or other extraneous material.

Having performed the operation which the surgeon has set out to do, it then remains to close the wound. Having satisfied himself that all bleeding points have been secured by ligatures, which may be either of silk, thread or catgut, the wound should then be sutured, bringing displaced tissues into

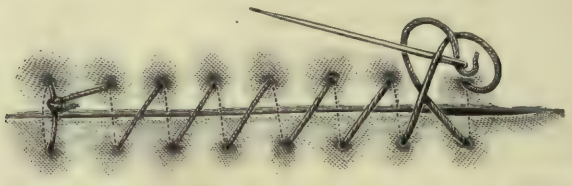


FIG. 25.—A simple continuous suture; at the end it is fixed by passing the needle through a loop which, when drawn tight, will form a slip-knot.

as near their former position as possible. The protecting clothes should not be removed until suturing of the skin is called for.

For the application of the ligature, see *Hæmorrhage*.

*Suture of wounds.*—Surgical needles of steel, straight, curved, or semi-circular, when used for perforating skin, must have the pointed end triangular, spear-shaped, or chisel-shaped (*Hagedorn's*). The round sewing needle cannot be passed through the skin, but is suitable for the deeper and softer structures and mucous membranes, as the needle makes only a minute ound hole. Fine sewing-needles should have a split eye to facilitate thread-

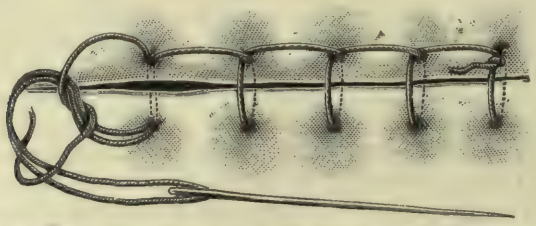


FIG. 26.—Continuous button-hole suture. The suture can be finished by drawing the double thread on the needle tight without allowing the single free end to be drawn through the last puncture; then the single free end is tied with the double thread on the needle.

ing. There are many kinds of needle-holders, but skilful fingers aided by dissecting forceps are best, or when necessary clamp forceps can be used. Needles are also fixed in solid metal handles, long and short; the finest of such are used for cleft palate, the stronger for hernia and for transfixing pedicles. A special needle for passing skin sutures on the lock-stitch principle is known as *Barker's*. A needle may have a slot near the point instead of an eye, for instance, *Reverdin's*. Unless there is ample assistance, needles should be threaded beforehand to avoid delay.

Suture may be inserted by the continuous or interrupted methods.

(*a*) *Continuous.*—1. Simple continuous suture. The sutures are passed through the wound at right angles to the line of union, which they cross

obliquely above the surface (Fig. 25). If passed obliquely, they can be made to cross over the line of the wound at right angles.

2. A button-hole or looped continuous suture (Fig. 26). The needle after each puncture being passed through the loop, the suture crosses the line of

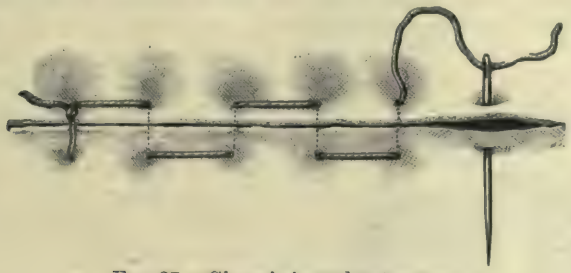


Fig. 27.—Glover's in-and-out suture.

union transversely. This suture is capable of bearing some tension, and keeps the edges of the wound from turning in.

3. A glover's in-and-out suture (Fig. 27), also called a mattress suture. This suture pierces the line of union at right angles, and then returns in the reverse direction, without crossing above the surface, so that, on being drawn tight, the edges of the wound tend to pout. Thus, when passed from within

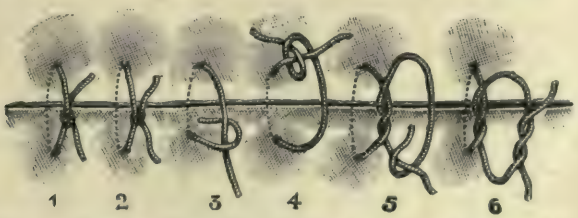



Fig. 28.—Interrupted suture. 1 to 6. The knots in various stages. 3 and 4. The first hitch, which can be drawn so that the knot lies to one side of the line of union.

the bowel, the suture can be used to turn mucous membrane inwards—as in Connell's intestinal suture—or, on the other hand, skin, *e.g.*, of the scrotum, outwards.

Continuous sutures can be fixed at any point by making a back stitch, or are tied at the end as shown in Figs. 25 and 26.

(*b*) *Interrupted suture.*—1. Simple interrupted suture, tied by reef knots (see Fig. 28, 1 to 6); or if there is much strain a second loop is made in the first hitch, the surgeon's knot (see Fig. 30). For silkworm sutures the first hitch of a surgeon's knot will suffice.

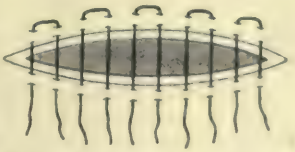


Fig. 29.—Quilted, square or Halsted's suture.

2. Quilted square sutures have several variations. A double-threaded suture is passed (as seen in Fig. 29) twice in and out on each side of and at right angles to the line of union. On drawing the suture tight the edges of the wound are turned in, hence its use as a sero-muscular suture in intestinal surgery. Applied in the reverse way in arterial suture, it approximates the endothelial surface by turning the edges outwards. Other forms are used in Macewen's operation for hernia, and in tendon anastomosis.

In uniting a wound, the suturing may be :—

(i.) *Cutaneous.*—Continuous or interrupted, as described above, removed after a week or so by cutting to one side of the knot.

(ii.) *Subcuticular.*—The suture is passed in and out and from side to side through the deep layers of the dermis without coming to the surface, except at each end of the wound, where the suture is brought out and is fixed to a pledget of gauze, or passed through a button and fixed by a split shot, etc. The suture is removed by cutting through one end and pulling on the other, but this may be painful from kinking. If fine catgut is used, the suture may be buried and left to be absorbed.

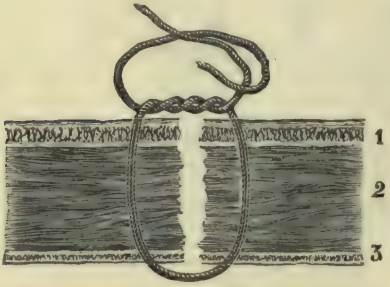



FIG. 30.—Deep interrupted suture, passed through all the layers of a wound (*e.g.*, the abdominal wall, 1, skin ; 2, muscle ; 3, peritoneum), and tied by a surgeon's knot, *i.e.*, by making a second loop in the first hitch.

(iii.) *Deep interrupted sutures* passed through all the layers (Fig. 30) of the wound.

(iv.) For *suturing in layers* buried sutures are now largely used in all deep wounds where muscles tend to retract ; in the case of the abdominal wall, peritoneum is united to peritoneum, muscle to muscle, aponeurosis to aponeurosis, skin to skin (Fig. 31).

(v.) *Primary suturing.*—The sutures are inserted and drawn tight at the end of the operation.

(vi.) *Secondary suturing* is suitable for septic wounds and suppurating cavities, which are kept open until rendered healthy by dressing, and then united by suture.

*Michel's clips* were much in use a few years ago, but have not continued so. They are often difficult to apply nicely ; they cause pain by sticking to the bandage, and also pain in removing. They were specially recommended for the fine skin of the face, but must be pinched tight, and a fine silk suture painted over with iodine is preferable.

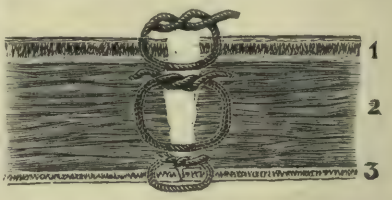



FIG. 31.—Suturing by stages. 1. Skin sutured to skin. 2. Muscles sutured to muscles. 3. Peritoneum sutured to peritoneum. Either continuous or interrupted sutures are used.

8. **Drainage.**—A non-infected wound in which hæmorrhage has been completely arrested, and in which there is no cavity for blood or serous discharges to collect, does not need to be drained. Whenever a large area has been opened up, as in the case of the neck, armpit, or scrotum, it is generally desirable to drain for a day or two ; if not, serum may collect, and although sterile, it separates the wound surfaces and necessitates passing a probe (practically secondary drainage), and so healing is delayed. The insertion of a sterile rubber tube, oil-silk drain or filiform drain composed of strands of fishing gut, wire, etc., will not delay healing if removed after a day or two.

The absorption of sterile serum in considerable quantities induces a temporary toxæmia, malaise, headache, fever, etc. Some wounds require to be drained for a special reason, *e.g.*, in operations on the thyroid gland, not

only for the removal of blood serum, but also of thyroid exudation, which if absorbed may induce symptoms of hyperthyroidism.

*Drainage tubes* are generally made from various sizes of red rubber tubing which has been sterilised by boiling for half an hour in plain water; they may be stored in sealed sterile glass vessels. Holes may be cut in the sides of the tube; a length of tubing without side-holes may be employed to siphon over into a vessel placed at a lower level beside the bed, *e.g.*, in the removal of fluid from the bladder or other cavity. A drainage tube should be prevented from slipping inwards by transfixing its outer end with a safety-pin and suturing to the skin of the wound. Special tubes for empyema, perineal bladder drainage, etc., have flanges for the same purpose. Other drainage materials may be used, *e.g.*, strips of oiled silk, the fingers of rubber gloves; gauze should not, however, be used for this purpose.

9. **The dressing of the wound.**—If after suture of a wound no oozing is to be anticipated, it may be simply painted over with iodine solution and left exposed to the dry air, a method of treatment suitable for face surgery; but this entails some risk of injury, *e.g.*, by scratching from an involuntary impulse on the part of the patient. More protection is afforded by applying a layer or two of sterile gauze or wool and fixing it down by collodion, avoiding contact of the collodion with the actual line of union.

The general rule is to apply several layers of gauze; this should be of the plain aseptic variety, and not that impregnated with antiseptics. After painting the line of suture with iodine solution, the gauze should be taken from a sterilised packet or drum and applied dry. Over the gauze is placed a layer of wool and the whole firmly bandaged to keep it in place.

10. **Bandaging.**—A bandage should apply equable pressure on the wound with the object of checking oozing, and will afford the greatest comfort to the patient after laparotomies, hernia operations, etc. The best are made of elastic woollen material; cotton and linen bandages are less elastic and less comfortable. The roller bandage is applied in various ways, a spiral, figure-of-eight, spica, etc. The first application should be firm without causing undue constriction. In the limbs this is avoided by bandaging from the extremities upwards and then keeping the limb elevated. Usually after twelve hours a tight bandage may be eased to the comfort of the patient. A roller bandage is generally the most suitable for the limbs; for the trunk, a many-tailed bandage has the advantage; for the perineum, a T-bandage; and for the head, a triangular handkerchief. When there is much tension on the line of suture, strapping may be applied over the inner layer of gauze. Generally the dressings should be kept dry as far as possible; therefore the bandaged part should be kept outside the bed-clothes or air should be allowed to circulate by raising the bed-clothes by a cradle.

"Protective," "oiled silk," "jaconet" is used as in colostomy to prevent gauze from sticking to the surface of the intestine. "Mackintosh" may be employed to protect the dressing from being soiled by urine, and is used to keep in moisture in fomentations and wet dressings.

11. **The bed to be prepared** for a patient should be narrow and stand high; it should have a firm, smooth mattress, and with modern methods of splinting the latter does not require to be rendered more rigid by placing boards underneath in the case of fractures. Under the patient is laid a mackintosh sheet, covered by a linen one. The bed-clothes must be quite dry, being well aired just beforehand, and the patient should be wrapped in a hot blanket. If hot-water bottles are used to warm the bed, they should be removed before the arrival of the patient; unless this rule is adhered to, the patient in

moving before regaining consciousness may come into direct contact with a hot-water bottle ; a troublesome burn, taking weeks or months to heal, may ensue.

12. **After-treatment of an operation.**—The *position* of the patient requires careful attention. That which is most comfortable is semi-reclining, with the back well supported by pillows, which should also be placed under the partially-flexed knees. In some cases, especially after head and neck operations, it is desirable that the patient should lie flat.

*Post-anæsthetic vomiting* will soon begin. It varies, with different individuals and the administration of the anæsthetic, from vomiting which takes place once up to that lasting for twenty-four hours or more. During the period of unconsciousness the patient should not be left unattended. The head should be turned to one side so that the vomit can run out of the lower angle of the mouth into a bowl or on to a pad of lint. In the case of neck wounds, care should be taken to see that contamination does not take place from the vomit running on to or under the bandage. Should this occur, the latter must be changed.

*Restlessness* is a frequent post-operative condition during the stage of semi-consciousness, especially in alcoholic subjects. The patient can usually be easily controlled, but it may become necessary to administer drugs to keep him quiet ; this also is a sign of hæmorrhage, the possibility of which must always be borne in mind.

*Cyanosis*, due to the falling back of the tongue in the unconscious state, can be easily controlled by holding the jaw forwards and, if need be, by pulling the tongue forwards with forceps. The latter should be avoided if possible.

If it is likely from the nature of the operation that the patient will have unendurable pain, aspirin may be administered in gr. xxx. dose, given in half a pint of saline per rectum, a method which has the additional advantage of providing fluid to the tissues and frequently prevents the onset of thirst. Morphia may also be given subcutaneously before the patient wakes up.

*Post-operative collapse* also demands attention at this stage (see pp. 172 and 304).

During the first forty-eight hours especially a careful record should be kept of all that happens to the patient. Such a record should contain information as to sleep, pain, vomiting, temperature, pulse-rate, respiration rate, action of the bowels, food taken, condition of the tongue, passage of urine, and condition of the dressing.

*Sleeplessness* is common on the first night after an operation, due either to vomiting or to pain. If due to the latter, it can be relieved by morphia injected subcutaneously or nepenthe by mouth. If wakeful, but without pain, a dose of aspirin, a mixture of chloral and potassium bromide, or some other hypnotic should be given in preference.

*Pain* usually is related to the area of the wound and is increased by movement, vomiting, coughing, etc. ; in abdominal wounds it may be referred to other regions, due to distension of the bowel, which should be relieved. Pain may be relieved by drugs if necessary, and should have disappeared within forty-eight hours ; if at the end of that period it persists, the wound should be examined and a cause looked for, *e.g.*, hæmatoma, inflammation, suppuration, etc. If no such cause is found, it may be due to the greater susceptibility of some patients.

*Vomiting* is most frequently due to the anæsthetic, and passes off within a few hours. Ether is the commonest cause, owing to the saturation of the saliva which is swallowed and consequent irritation of the gastric mucosa ; so long as this remains in the stomach the vomiting will persist. The

patient should be given a pint of warm water to which a teaspoonful of sodium bicarbonate has been added; this will dissolve the mucus, and acting as an emetic, cause the patient to vomit, which will relieve him. If this fails, a minim of tincture of iodine in a wineglassful of cold water or *acidi hydrocyanici dil.* may bring about the desired result. Iced champagne is sometimes useful. Ice-bags may be applied to the epigastrium. The stomach may even be washed out with a tube. Injections of atropin in small doses may be used. If these all fail, the urine should be examined for diacetic acid as a sign of acidosis, and, if the latter is found, intravenous injections of sodium bicarbonate administered. In abdominal conditions intestinal obstruction may be present, and must obviously be relieved. During the acts of vomiting the patient or the nurse should support the wound to relieve the pain and, in abdominal wounds, to prevent the tearing out of the stitches.

*Temperature.*—This should remain normal after all aseptic operations, or at most rise to 100° during the first twenty-four hours owing to the absorption of serum; should a greater or persistent elevation occur, the wound should be examined to be certain that inflammatory conditions are not arising; if there is no indication of this, pulmonary complications should be looked for, especially if coincident with an increase in the respiration rate. A subnormal temperature within the first twenty-four hours is indicative of post-operative shock.

*The pulse-rate* may rise as the result of loss of blood; this is associated with small volume and low pressure. If the frequency remains up, it usually indicates similar conditions to those above mentioned. The possibility of septicæmia must not be forgotten.

*If the respiration rate increases* on the second or third day after an operation, some pulmonary complication must be suspected. This may occur without or before any physical signs can be distinguished in the chest. Pulmonary complications are most commonly observed in old or feeble persons.

*Action of the bowels.*—Within the first twenty-four hours, especially after abdominal operations, the patient may suffer from flatulence; this can be relieved by the passage of a rectal tube or a soap and turpentine enema (℥j. to the half-pint). The following makes a good enema: Ol. Terebinth. ℥j. ss., Ol. Ricini ℥j., Tr. Asafetida ℥j., En. Sap. to one pint. In all cases the patient is rendered more comfortable by a motion about twenty-four hours after an operation. Collections of wind in the bowel set up irregular peristalsis which causes uncomfortable griping pains; in abdominal conditions these may be so severe as to simulate general peritonitis; all these symptoms will pass off when the bowel acts. Castor oil (℥j.) is the best post-operative aperient, especially when the gut has been handled, but many others may suffice—liquorice powder, cascara sagrada, calomel, etc.; the last is best followed up in six hours by a saline aperient. An enema occasionally produces an erythematous rash, which may occur on the limbs, face, or trunk. It passes off rapidly.

*Diet.*—The patient should be kept on a light diet until after the bowels have been opened. The normal diet in most cases can then be returned to. During the first twelve hours fluids only can be taken, owing to the tendency to vomiting. Milk should be avoided as far as possible, as it tends to increase flatulence. In those cases where the vomiting is excessive, two-hourly rectal salines should be introduced, as these will relieve thirst.

Special dieting is required in some abdominal conditions, and will be dealt with elsewhere.

In some cases, *e.g.*, after laryngectomy, nasal feeding may have to be resorted to.

After an operation there may be some difficulty in getting the patient *to pass water*, especially where the pelvic organs have been handled. The passage of a catheter should be delayed as long as possible. In the majority of cases a change of position, the use of a hot enema, or the application of hot fomentations to the hypogastric and perineal regions will help, but if this fails a catheter must be passed.

The *skin* must receive attention, especially when the patient is old and thin. Parts liable to pressure must be kept well cleansed and dry. Washing with spirit, followed by the application of a drying powder, will help to maintain a good condition. The patient's position should be changed frequently, and, if need be, he can be placed on a water bed. Inspection of the bandages should be made frequently to see that discharges from the wound are not soaking through, especially if hæmorrhage is suspected; also, care must be taken that the wound does not become exposed or the dressing soiled with vomit, urine, fæces, etc.

**Delirium in surgical cases** is generally due to the absorption of toxins, complicated or not by alcoholism. Mental excitement occurs in emotional and weak-minded patients under the strain of an accident or operation, and may possibly be the immediate cause of the patient becoming insane. But in most cases there is some source of toxic absorption, to which may be added degeneration due to alcohol. As to the latter, the results of alcoholism in the patient may be obvious, or his habits may be well known; on the other hand, alcoholism may have been previously so concealed as to be unsuspected.

After an anæsthetic a young adult may have a period of delirium, due to the idiosyncrasy of the patient to the drug. After a head injury there may be cerebral irritation. Delirium due to toxæmia and septicæmia may be nocturnal only, intermittent or continuous.

The delirium chiefly caused by alcoholism, or *delirium tremens*, is distinguished by the relative absence of fever, and its low muttering or busy character. The patient talks constantly to himself; he may answer rationally and then at once relapse. He has delusions that animals or devils are under his bed or in the air, or he is suspicious of his friends. His hands tremble when stretched forward with the fingers outspread; his skin is moist and has a fatty feel as distinguished from the dry, shrunken skin following pyogenic infection; his pulse is full and soft, with a tongue which is large, tremulous, tooth-indented, and coated with creamy fur. But the severe stages of alcoholic delirium do not differ from the infective, and correspond with the so-called typhoid state.

*Treatment.*—The essential treatment is to arrest and remove the source of the toxæmia. Meanwhile the patient must be fed. This can usually be managed by judicious firmness and coaxing by the nurse, alcoholic patients being generally ready to drink anything although they refuse solid food. Alcohol should not be given; it will only retard or prevent recovery. Should the patient refuse fluids, he may yet let the nurse administer enemata. Only when absolutely necessary should forced feeding through a stomach tube be resorted to, for the struggling much exhausts the patient. The safest drugs are bromide of potassium (grs. 20—30) and chloral (grs. 10), given frequently so as to keep the patient drowsy, and if possible to anticipate the onset of the delirium. An injection of morphin can only be given at some risk. It may be necessary to administer small quantities of chloroform, and if the violence of the delirium can be temporarily arrested,

the bromide and chloral may then induce sleep. Seclusion is of great importance; visits of friends only tend to excitement. Such patients must never be left alone, for they may be seized at any time by a suicidal impulse. Manual restraint is much the best, but it may become necessary to strap the patient down in order to prevent him from injuring himself, *e.g.*, by tearing off bandages and splints and converting a simple into a compound fracture.

**Treatment of possibly infected (accidental) wounds.**—The description of the treatment of wounds described above applies to those in which infection is not present, either bacteriologically proven or known from the nature of the wound.

It is now proposed to discuss the treatment of an accidental wound such as arises from a street or machine accident, or some other similar cause, in which it is probable that some bacteria have obtained an entrance.

The main principles of aseptic surgery still hold good. The preparation of patient, theatre, instruments, etc., demands the same scrupulous care and consideration. So far as the skin is concerned, even greater care is called for. The differences may be classified under the headings :—

1. First aid.
2. Examination of wound.
3. Preparation of wound.
4. Treatment of wound.

1. **First aid.**—As a rule there is no available antiseptic in civilian practice, so that beyond covering the part, after washing it with water, with some clean material, nothing further is possible.

2. **Examination** for nerve injury especially should be made before the patient is given an anæsthetic and the degree of injury investigated as far as possible.

3. **Preparation of the wound.**—Except in very minor injuries, an anæsthetic is required for the adequate cleansing of a wound. The skin around the wound for a wide area must first be thoroughly cleansed by the free use of soap and water. All dirt should be washed off, preferably by the use of a scrubbing brush, and all hair removed by a razor, which, in addition, helps to get rid of dirt adhering to the skin and hair. The wound itself should be protected by packing with sterile gauze during this procedure. If necessary, dirt which cannot be removed by this means may be cleaned away by the use of turpentine. Finally, the skin should be cleansed with ether, and the subsequent application of an alcoholic solution of picric acid (3 per cent.), which should be allowed to dry by evaporation. With strict aseptic precautions the wound can now be examined.

4. **Treatment of the wound.—Excision of damaged tissues.**—Great care should be taken in estimating the extent of the wound, and observation should be made especially with regard to the damage to important structures, *e.g.*, nerves, vessels, bone, etc.

With the exception of cleanly incised wounds, such as may be produced by glass, it is usually necessary to treat first the damaged tissues by excising those portions of them which have been devitalised, so as to give a clean margin to the wound. This applies not only to the skin, but also to the fasciæ, muscles, and *completely* detached portions of bone. In some cases it may be necessary to remove considerable portions of these tissues in order to get the best results. If it is possible to excise the whole of the damaged tissue, as in the case of a gutter wound of the skin and superficial muscular layer, this should be done. In the deeper wounds the external openings should be enlarged so as to estimate the extent of the damage after having

removed the lacerated superficial tissues. In the case of a perforating wound of a limb, this procedure should be carried out from both ends, care being taken not to damage large nerves or blood-vessels. Any foreign material that may have penetrated into the wound, *e.g.*, clothing, dung, etc., should be sought for and removed. All bleeding points must be carefully ligatured, for hæmorrhage into a closed wound aids infection. When the surgeon is satisfied that all possibly infected tissues have been adequately dealt with, a variety of procedures are open to him :—

(*a*) The wound may be washed out with water or a dilute solution of some antiseptic, *e.g.*, biniodide of mercury, flavine, potassium permanganate. In doing this all pockets of the wound must be carefully dealt with. The wound may then be closed in layers by *primary suture*, care being taken to obliterate by the use of deep sutures any small cavities that are liable to be formed. Any divided tendon or injured nerve should be sutured and a fracture suitably dealt with. This is the ideal method of treatment. If there is still some doubt as to the possibility of infection, the wound may be "*bipped*" prior to the suturing. This method consists, firstly, in making certain that all bleeding points have been ligatured; secondly, flushing out the wound thoroughly with alcohol, which may be distributed through it by packing a piece of gauze soaked in alcohol into all the pockets and allowing it to remain there for a few minutes; and finally, after the removal of the gauze, smearing and gently rubbing into the tissues a small amount of "bipp" (an antiseptic paste consisting of bismuth, iodoform, and paraffin) in such a way that, when the procedure is finished, there is no excess lying in the wound; if there is, such should be removed. If there is any oozing, a drainage tube or oiled silk drain should be left in the wound for twenty-four hours.

(*b*) Instead of this method *delayed primary suture* may be adopted. This may be applied to all types of wounds, including compound fractures, in which, after the devitalised tissues have been excised, it is considered that infecting bacteria may have obtained an entrance. After excision the wound and its interstices are packed with gauze, or gauze soaked in a dilute solution of some antiseptic, which is little likely to damage the tissues, but which at the same time is a good antiseptic. Flavine, eusol or ether is suitable for this purpose, especially the first. Dressings should be placed over the surface, soaked in the same solution, and the bandages applied so as to keep the wound at rest, in the case of a limb on a splint. At the end of forty-eight hours the packing is removed by means of forceps after the skin around the wound has been dealt with in the ordinary pre-operative manner. Great care should be taken not to insert the fingers into the wound, or to cause bleeding while removing the pack. If the surface of the tissues is dull, sticky, devoid of granulation, or discharge other than serous, it can be sewn up completely with the same precautions as for primary suture. If doubtful, bacteriological examination should be made and the wound repacked for a further period or dealt with by any other suitable method.

In 80 per cent. of efficiently excised wounds healing by first intention will take place.

By either of these two methods rapid healing is attained, painful dressings are avoided, the smallest amount of scar tissue is formed, thus limiting the subsequent degree of contraction and possible deformity.

(*c*) *Carrel-Dakin treatment.*—This treatment was devised as a means of applying a non-irritating antiseptic constantly to the surface of exposed tissues, so as to prevent infection in a wound or to eradicate it if it exists, and avoid

further dissemination. The antiseptic used is a neutralised solution of sodium hypochlorite (the preparation of the solution requires to be done very carefully). It is said not to damage living tissues and, at the same time, to be a powerful bactericide, and will act in the presence of serum. The necessity for keeping it constantly in contact with the tissues is due to the fact that, if applied on gauze, it soon loses its bactericidal properties. Carrel overcame this difficulty by allowing it to run from a tank raised to a suitable level through perforated fine rubber tubing at such a rate that it did not soak through to the outer dressing. One or two drachms are run in from the tank hourly. By means of a single branched glass tube the solution passes through the numerous pieces of tubing into all the recesses of the wound. The tubing is kept in position by gauze soaked in eusol. It requires to be washed through every twenty-four hours, but need not be removed until the process has completed its object.

The condition of the wound is investigated bacteriologically daily until sterile, when it can be sutured. This method requires considerable experience and patience for its efficient use, but it is a valuable one.

(*d*) *The salt pack method.*—It has long been recognised that a hypertonic solution of salt in the tissues would cause the exudation of serum from them. The effect of this is to wash out any bacteria which may be lying deeper than the surface and, at the same time, bring into action the bactericidal substances of the blood which kill the micro-organisms. This is a physiological process rather than an antiseptic one. It is carried out in practice either by allowing a hypertonic solution of salt to run continuously through the wound by a method somewhat similar to that described above, or else by placing tablets of salt wrapped in gauze into all the pockets of the wound and allowing them to remain there for some forty-eight hours to four days. In this way a wound will very rapidly clean up, but the latter method has the disadvantage of causing the wound to become extremely foul prior to its becoming better.

(*e*) Another method is to pack a wound with some form of antiseptic in the form of a paste: phenol, bismuth and salicylic acid have all been used for this purpose, but have been given up.

After any of these methods, when healthy granulations have formed, the wound can be sutured. As a preliminary measure, the tissues should be bacteriologically examined prior to this form of suture, known as *secondary suture.*

**Antiseptics.**—Those in general use may be classified into certain groups, thus:

1. Salts of various minerals, *e.g.*, mercury, silver, gold, copper, and zinc.
2. Mineral acids.
3. Alkalis.
4. Halogens, including chlorine itself, bleaching powder, sodium hypochlorite (eusol), neutralised sodium hypochlorite (Dakin's solution), dichloramine T., iodine, iodoform.
5. Coal-tar derivatives: carbolic acid, creosol, B-naphthol, salol, ichthyol, izal, lysol, guaiacol, picric acid.
6. Thymol.
7. Alcohols and ethers, including acetone.
8. Dyes: flavine, methylene blue, brilliant green, malachite green.
9. Hydrogen peroxide, potassium permanganate.
10. Reducing agents: formalin and sulphurous acid.

Many of these are not in constant use, but the purposes for which the more important of them are used will now be discussed.

1. *Salts.*—The salts of mercury are those most frequently used, viz., the perchloride and the biniodide. The former is one of the most powerful antiseptics known. Unfortunately it combines with albumen, and thus its antiseptic properties are lost. Surgical instruments should not be placed in this solution, as it causes them to turn black. The biniodide, which is not such a powerful antiseptic, has this advantage, however, that it does not tarnish the instruments. Mercurial poisoning may follow the use of this solution if placed in contact with raw tissues for a prolonged period. The perchloride was at one time used as a means of sterilising dressings, but now that sterile gauze has taken its place it is no longer required for that purpose. In combination with methylated spirit, to a strength of 1 in 500, the biniodide is commonly used as an antiseptic for the hands after they have been thoroughly scrubbed with soap and water. Some surgeons use solutions of these salts to wash out their wounds during operations, but in the practice of aseptic surgery they are not required. The salts of silver and gold are still more powerful, but they are very expensive.

2. *Mineral acids.*—These are very seldom used, with the exception of boracic acid, which is a very feeble antiseptic. A saturated solution of the crystallised powder is used for washing out the eyes in cases of conjunctivitis, the bladder prior to cystoscopy, in fomentations as applied to wounds, but sterile water serves the same purpose. Some of the stronger acids, such as fuming nitric, can be used for cleaning out glass vessels when they are required urgently.

3. *Alkalis* are not much used in surgical practice.

4. *Halogens.*—*Iodine* is the one which is very commonly employed; it is used in an alcoholic solution (2½ per cent. iodine in rectified spirit), and is painted on to the skin preparatory to operations; it should be allowed to evaporate before the operation is commenced. It is also used in the form of a tincture (a drachm of the tincture to a pint of water) for washing out cavities, especially those with a foul discharge. In this form it makes a convenient bath into which to place a limb, the seat of multiple wounds. During the war it was largely used as a first-aid agent to prevent infection; it is useful for this purpose in small wounds, but of very little value in the larger ones, owing to the fact that all pockets of infection cannot be reached. *Iodoform* is a lemon-coloured powder with a characteristic odour. It has largely fallen into disuse of recent years. It acts by virtue of the liberation of iodine when it comes into contact with the tissues. More recently, in combination with bismuth, iodoform and paraffin, it has been used as "bipp" in the treatment of wounds. It is also used as an emulsion in glycerin for injecting into a tuberculous cavity after the aspiration of a tuberculous abscess. This preparation must be freshly made, for, if stale, free iodine is liberated, which may act as an irritant. Care must be taken in the use of the drug, as it is liable to set up symptoms of poisoning characterised by nausea, vomiting, malaise, rapid pulse, mental depression, sleeplessness, delirium, and hallucinations; patients may die of it. If recognised early, recovery can be brought about by stopping the use of the drug; this is not always the case, however, for the symptoms may persist for a very long period after the drug has been discontinued.

*Sodium hypochlorite* (eusol) is a very powerful antiseptic, but, by virtue of the alkali in it, damages the tissues with which it comes into contact. This was overcome by neutralising the alkali by a rather elaborate technique (Dakin's solution). The latter is the drug used in the Carrel-Dakin method of treating infected wounds.

5. *Coal-tar derivatives.—Carbolic acid* is the most important member of this group and is still largely in use. It is employed in strengths varying from 1 in 20 to 1 in 80. It may be used in the latter strength for the rapid sterilisation of instruments. It is liable to give rise to symptoms of poisoning, characterised by a change in the colour of the urine to an olive green or black. If used as a local dressing to the skin, even in very dilute solutions, it causes destruction of the cells thereof, and may produce gangrene. *B-naphthol and salol* are used as intestinal antiseptics. *Ichthyol* in the form of an ointment is frequently used for skin infections. *Izal* serves as an excellent throat-wash or paint. *Lysol*, especially when mixed with methylated spirit, serves for sterilising instruments. *Picric acid* in an alcoholic solution has largely replaced iodine as a skin antiseptic on account of its equal efficacy and its greater cheapness.

Only the purest form of carbolic acid should be used. Undiluted carbolic acid immediately destroys all micro-organisms in contact with it without destroying tissues beyond the surface, and it has been used for swabbing out limited areas of necrosis and foul ulcers. It is also useful for swabbing out the interior of bone cavities, *e.g.*, after the removal of a myeloid sarcoma. It is a local anæsthetic. Small plugs of wool squeezed out of undiluted carbolic acid can be inserted into a hollow tooth to relieve tooth-ache. Care must be taken to see that it does not run over the mucous membrane. For the relief of irritation it is also useful in the treatment of pruritus ani.

6. *Thymol.*—Thymol is one of the most powerful antiseptics known, and is mostly used as a preservative. It is very expensive.

7. *Alcohols, ethers, and acetone.*—These drugs are largely used for cleansing purposes. Ether and acetone are both useful for removing grease from the surface of the skin. Ether may be used for soaking gauze which is being packed into a wound; it has also been used in the treatment of general peritonitis. Methylated spirit serves as a useful agent for sterilising sharp instruments prior to their use at an operation; it also prevents their becoming rusty after boiling if immersed in it before they are put away.

8. *Dyes.*—These have come mostly into use during the war. *Flavine* is a very powerful drug, and as it is said not to damage the cells of the living tissues, it becomes a very useful antiseptic when used in a strength of 1 in 10,000; others are *brilliant green, brilliant purple*, etc.

9. *Hydrogen peroxide* (*a solution of* 10 *to* 20 *volumes per cent.*).—This is a fluid containing oxygen in the nascent state, which is liberated very easily in the presence of any oxidisable substance. It is not a powerful antiseptic, but serves to remove *débris* from a wound by the bubbles of gas which it produces; it is thus largely used for irrigation purposes in all septic cavities, but should be removed after the irrigation by a saline solution.

*Potassium permanganate* is one of the most powerful antiseptics in our possession. It is most frequently used in connexion with urinary surgery for washing out the urethra and bladder in cases of infection; it is also valuable in the treatment of mouth infections and for foul-smelling empyemata. It acts by yielding oxygen, when its colour is lost and the solution becomes inert. Stain on linen is removed by carbolic acid, 1 in 40. A solution of salicylic acid is even more useful in decolorising.

10. *Reducing agents.—Formalin* is not used in the tissues owing to its destructive properties on the cells, but its vapour serves a very useful purpose in sterilising catheters, and the solution in preserving museum specimens. *Sulphurous acid* is used for the cleansing and sterilisation of marine sponges.

It will be observed that most of these drugs are not used on the human tissues owing to their destructive powers, but they each and all of them serve a useful purpose in antiseptic surgery.

*Sterile water.*—The tap-water in a properly working hot-water system is practically free from pathogenic micro-organisms. Drinking water boiled for half an hour in a kettle may be regarded as sterile ; if transferred to another vessel, the latter must have been previously sterilised and must be kept covered.

*Sterile salt solution.*—Saline solutions have been distinguished as *isotonic* (containing 9 grms. to the litre; 80 grns. to the pint, or 1 oz. to the gallon), *hypertonic* (above this), and *hypotonic* (about 6 grms. to the litre).

## The Healing of Wounds.

The healing of a wound as here described will relate chiefly to the skin and the soft tissues ; the special processes of repair connected with bones, muscles, nerves, etc., will be dealt with elsewhere.

The process of repair, which, speaking generally, is the same in all tissues, is similar to the regenerative stage of inflammation ; it differs from it in that bacteria are not present. With the smallest degree of preliminary emigration of leucocytes and pathological exudation, there is regeneration of the tissues through the agency of fibroblasts and proliferating epithelial cells ; these vary according to the amount of damage caused to the tissues by the wounding. This process is spoken of as healing by *first intention.* The presence and activity of pyogenic micro-organisms in every way renders the process of regeneration similar to that described under the heading of *Inflammation ;* it is thus no longer a primary but a secondary process, and healing only occurs when the inflammation and suppuration have subsided. This is spoken of as healing by *second intention.*

**Healing by first intention.**—After a clean incised wound has been sutured, the necessary precautions having been taken to prevent the introduction of bacteria into the tissues, the parts are kept at rest so that the edges of the wound remain in contact. Healing and union will occur without any naked-eye evidence of inflammation. The edges of the wound will not, from the time of their suture onwards, present any external differences. If an attempt is made within the first week to separate these edges, they will be found stuck together by a white adhesive material, but after a period of eight days, as a rule, this separation can only be carried out with difficulty ; at the end of a week the line of union becomes red as the result of vascularisation of the newly-formed tissues ; ultimately this line becomes paler and paler, and a thin white streak alone indicates the site of the injury. In certain parts of the body, with special care taken in the process of suturing, it may become almost imperceptible. If a cut is made into this wound it will be found that the edges have become firmly united to each other by the formation of white fibrous tissue. If from any cause the surfaces of a wound are not brought accurately into contact, the space becomes filled up with coagulated blood ; blood may also exude on to the surface and form, when it dries, a scab. The presence of such blood-clot between the margins of the wound is not a good thing, and tends to leave a weak scar ; it also forms a channel through which bacterial infection has a greater chance of occurring than when the edges of a wound are brought into accurate apposition. It is desirable, for the latter reason, that blood-clot formed in this way should be removed.

**Microscopical appearances of healing by first intention.**—Immediately after the injury the blood-vessels which have been divided contract and

retract, and the blood in them becomes clotted, the process of thrombosis being set up, except in the case of the large blood-vessels which only undergo this change when they have been ligatured. An inflammatory reaction is set up in the wound; leucocytes and serum are poured out into the tissues; the tissue around the wound also becomes hyperæmic and swollen; when united, the edges become stuck together by the adhesion of the fibrin which is deposited on the two surfaces. The endothelial cells and the connective-tissue cells proliferate, the leucocytes which were first cast out from the blood-stream rapidly disappearing. New blood-vessels begin to make their appearance among the small round cells, being produced by the budding of columns of endothelial cells from the original capillaries of the part; these, uniting with similar columns from the opposite side of the wound, finally have channels formed in them and produce the new blood-vessels. When this has occurred, a separation of the edges of the wound will cause bleeding owing to their rupture. The small round cells derived from the connective tissues, known as fibroblasts, become elongated and eventually form bundles of fibrous tissue. In addition to the newly-formed blood channels, these fibres help to unite the two edges of the wound and constitute *scar tissue*. The redness already described is due to the large number of blood channels amongst these fibres. The fibres then slowly, but steadily, contract, drawing the edges of the wound closer and closer together, and at the same time, by their contraction, cause the disappearance of a large number of the newly-formed blood-vessels, and the scar changes from a red colour to white. During the process of healing of the deeper tissues by the formation of fibrous tissue the epithelial cells on the surface of the skin also proliferate and cover over the underlying structures; in the case of a wound with accurately apposed edges this process is reduced to a minimum. Amongst this new epithelium there are no sebaceous glands, hair follicles, or sweat glands. Any blood-clot which may have formed in the wound or between its edges is removed by phagocytosis on the part of the leucocytes.

Healing by first intention is prevented by:—

1. Infection by micro-organisms.

(*a*) In the case of a clean wound, by the failure of prophylactic measures.

(*b*) In the case of an accidental wound, from the impossibility of removing, or the failure to remove, infected material which has been carried into it at the time of the accident.

(*c*) Infection through the circulation from an existing infected focus in some other part of the body.

2. Excessive injury to the tissues forming the margins of the wound by contusion, lacera ion, rough handling, or the excessive use of antiseptics.

3. Inaccurate apposition of the edges of the wound.

4. The formation of exudation underneath the wound or between its margins setting up tension, which will separate the margins and prevent the formation of new blood-vessels by compressing them.

5. An impaired state of health from general diseases such as alcoholism, albuminuria, diabetes, etc.

**Healing by second intention.—Naked-eye appearances.**—A wound the margins of which are not brought together because its surfaces are infected or because the surgical technique employed has not been able to get rid of a possible source of infection, or in which there has been such a loss of substance that it is impossible to bring the edges together, will heal by what is known as *second intention*. The surface of such a wound will undergo the changes described under the heading of *Ulceration*. In the first place, sup-

puration with a certain amount of sloughing will take place, and, when this is finished, healthy granulations will form between the separated margins of the wound. If now the edges and surface of the wound are well approximated, they will adhere and unite with the escape of a certain amount of discharge. The scar tissue which forms is ultimately greater in amount than in a wound which heals by first intention, and the contraction which follows thereafter will be greater also. This form of healing by second intention occurs in wounds in which secondary suturing can be applied. In some cases it is not possible to bring the margins together in this way, and then the ulceration will have to heal in the manner previously described; under these conditions the scar tissue which forms is greater still. The epithelial cells are allowed to grow over the surface of the granulations until it is completely covered, or else are introduced by means of a skin graft from some other part of the body in order to hasten healing. The amount of fibrous tissue is obviously greater with these conditions than when secondary suturing has been applied, and much contraction will follow. The skin on the surface will be thin and liable to break down under the effects of a slight injury; it is also frequently pigmented owing to the greater vascularisation of the part. The microscopic changes which occur have already been described under the heading of *Suppuration.*

**Diseases of scars.**—Scars or cicatrices are liable to certain affections, which may be enumerated as :—

1. *Painful scar*, due to involvement of the nerves in the scar tissue or pressure of the scar on the bulbous end of a divided nerve. This can be avoided by taking proper care to prevent the end of a divided nerve from coming into contact with a recently sutured wound. When a painful scar is present it is necessary to open it up and isolate the nerve adherent to it, and in the case of an infected amputation stump, in which this is most likely to occur, to remove a sufficient length of the nerve to prevent a recurrence of the same condition.

2. *Depressed or contracted scars* are often met with after burns, tuberculous and syphilitic ulceration, or adhesion of an underlying structure, and undergo excessive contraction. Contracted scars are liable to lead to deformities, which must be guarded against by suitable splinting, massage, etc., especially when healing takes place by second intention. If they occur, it may be necessary to excise the scar or perform some plastic operation to get rid of the deformity.

3. *Warty scar.*

4. *A thin cicatrix.*

5. *Ulceration.*

6. *Keloid.*—A keloid requires special mention. It is the name given to hypertrophied scars and puckered, scar-like tumours of the skin, usually the result of some mild or chronic infection. This form of scar may spontaneously disappear after a considerable period of time; it is, as a rule, unwise to remove it, for the second scar which forms is very liable also to be of this nature, although after excision a sound scar may form. It is much more commonly seen after operations on tuberculous lesions than anything else; the scar is raised, firm, elastic, smooth and red, and the condition usually extends along its whole length. In dealing with this scar, it is best as a rule to wait for its spontaneous disappearance; there is no form of treatment which is really satisfactory. The application of X-rays, radium, or Finsen light may help.

7. *Epithelioma*, which must be treated in the same manner as malignant disease elsewhere.

## Shock.

Although the modern surgeon has to a great extent mastered the problems of pain and of sepsis by the discovery of anæsthetics and of aseptic methods, the problem of shock still remains to be conquered. In spite of the enormous amount of work, both clinical and experimental, that has been done on this subject, our knowledge of the nature of shock is far from complete, and our means of combating it equally imperfect.

In the following abbreviated account of shock it is not intended to discuss the various theories that have been advanced in explanation of the phenomena of shock, but to deal strictly with the practical side of the question in so far as it affects the surgeon.

**The causes of shock.**—Although shock is most commonly due to the infliction of a mechanical injury, it may also result from the action of a psychic, a toxic, a thermal, or a chemical stimulus. It is the general reaction of the organism to a stimulus of variable intensity.

Of greater importance from the point of view of practice are those causes which may be regarded as predisposing rather than as exciting causes of shock. These will now be considered.

*Temperament.*—The susceptibility to shock of different individuals is extremely variable. The same is true to a great extent of different races and nationalities. As a rule the more highly organised the race, and the more keenly perceptive and imaginative the individual, the more liable is shock to occur. The highly educated and sedentary town dweller shows a far greater susceptibility to shock than the plethoric but healthy ploughman.

*Age.*—The two extremes of life show the greatest susceptibility to shock. The aged only apparently endure operations well. It is true that during the operation the immediate circulatory and other changes may be surprisingly small. The rebound is only too likely to be equally small. The converse is true of infants.

*Hæmorrhage and anæmia.*—Hæmorrhage is by far the most potent predisposing cause to the development of shock. In cases of traumatic shock due either to accident or to operation it is impossible to exaggerate its importance. The thoroughness and rapidity with which such hæmorrhage is controlled may well be the determining factor in the case. The total blood volume is reduced in shock by a loss of its fluid constituents, probably by transudation through the vessel walls. Hæmorrhage depletes the circulation still further, and embarrasses a heart already contracting on an insufficient return of blood. When the hæmorrhage has been extremely severe the very mechanism by which the blood makes good its volume by absorption of fluid from the surrounding tissues breaks down, and circulation founders in the toils of a vicious circle.

*Cold.*—This is only second to hæmorrhage in its importance as a factor in shock. The subnormal temperature of a shocked patient as registered by the clinical thermometer is due not only to a rapid loss of surface temperature, but also to the diminished generation of heat consequent on a reduced metabolism. When this is aggravated by such additional factors as cold and exposure, shock is increased.

*Exhaustion.*—Fatigue, whether it be mental or physical, is a predisposing cause to the development of shock. As causes of mental fatigue may be cited insomnia, pain, anxiety, fear, anger, and all intense emotions. On the physical side are great exertion, starvation, thirst, and exposure.

*Trauma as an exciting cause in shock.*—Trauma, as has been already stated,

is the commonest cause of shock amongst cases coming under the care of the surgeon. Special stress has always been laid on trauma of structures intimately connected with or forming an actual part of the central nervous system, such as the spinal cord. Clinical observation and animal experiments have recently emphasised the fact that the extensive laceration of tissue is capable of producing shock even in the absence of stimulation of nerves. Injury to a limb causes a general fall of blood pressure in animals protected from painful stimuli by a previous division of the cord. In addition to the nervous mechanism of shock, there probably exists one that is toxic. From the injured area are carried into the blood stream bodies capable of producing a fall in blood pressure. Extensive damage to tissue is therefore likely to provoke shock, apart from the question of the tissue's richness in nerve terminals.

**The signs and symptoms of shock.**—In spite of the difficulty of giving a precise and scientific definition of shock, the clinical picture it presents is not difficult to recognise. The patient is in a state of prostration, an abnormally low blood pressure and a failing circulation being the salient features of his condition.

The signs and symptoms of a patient in a state of severe shock, say as the result of a severe injury to a limb, are as follows: He lies quietly or indifferently on his back with general relaxation of his muscles. The face is pale and in severe cases slightly cyanosed, especially in the regions of the lips and ears. The features are pinched, and the eyes shrunken. The pupils are generally dilated, and react torpidly to light. The skin is cold to the touch, and often bathed in profuse perspiration. The pulse is weak, and perhaps imperceptible at the wrist. Its frequency is usually increased. Respiration is shallow, rapid, and irregular, and is often interrupted by a sighing expiration. The reflexes, although sluggish, can usually be obtained. As a rule the patient is completely apathetic, and unresponsive to questions. In severe cases he is unconscious, with loss of control of his sphincters. When able to give an account of his sensations he complains bitterly of cold and thirst. His distress is often aggravated by persistent vomiting, and his mouth and tongue become hard and dry. Secretions in general are inhibited, and the output of urine markedly reduced.

More exact methods of examination of the blood and circulation will reveal other points of interest. The sphygmomanometer is a great help, especially with regard to prognosis. A steadily rising pressure is an indication of a favourable reaction, provided that such a complication as gas gangrene can be excluded. The interpretation of blood counts is a matter of difficulty when, as is so often the case, shock is accompanied by hæmorrhage. In hæmorrhage the number of cells per cubic millimetre is diminished owing to dilution of the blood; in shock it is increased owing to concentration. Moreover, it has been shown that this concentration of the blood in shock is more marked in blood drawn from the capillaries than in that obtained from a vein, a point in favour of the existence of a capillary stasis in shock. That a concentration of blood owing to a loss of its fluid elements occurs in shock is likewise shown by the results of the estimation of the total blood volume. These not infrequently show that the total volume of blood has fallen to 50 per cent. of the normal.

**Treatment.**—Although no specific exists for the treatment of shock, a great deal can still be achieved in preventing its onset, and in diminishing its dangers when once it is established. The following are the most important items in the treatment of shock.

*Rest.*—Since the clinical picture presented by a shocked patient is one of

exhaustion, its best antidote is rest. A patient in a state of shock must be disturbed as little as possible. Everything must be done to allay pain or anxiety, and by protecting the higher centres from all painful stimuli, to promote sleep. Gentleness in handling cases, even when under anæsthesia, is of great importance. A rough surgeon can exhaust a patient who is in deep anæsthesia. When large nerve trunks must be divided in the course of an operation they should be "blocked" by means of a local anæsthetic. When shock is due to a smashed limb it must be efficiently splinted before it is moved. The introduction of the Thomas splint into the forward area in France diminished the mortality from fractured femur during the recent war by 30 per cent. Rest in its fullest sense is the chief weapon in the treatment of shock.

Although the idea of exhaustion of the bulbar centres is no longer accepted as an explanation of shock, the necessity of doing everything to ensure a good blood supply to these vital areas still exists. The low position of the head and the raising of the foot of the bed are therefore useful adjuncts to treatment.

*Avoidance of cold.*—Emphasis has been laid on cold as a factor in the production of shock. Loss of body heat must be guarded against by every possible means. Patients undergoing severe operation should be provided with thick woollen stockings, and such parts as do not enter into the area of operation should be adequately protected against exposure. Hot water bottles are of great use, but, owing to the dulled sensibility of the patient, care must be exercised not to inflict burns. The heating of the operation table and the temperature of the theatre become matters of prime importance when dealing with cases of shock.

*The administration of fluids.*—Shock, it has been seen, is associated with the loss of considerable amounts of body fluids through excessive perspiration, vomiting, or hæmorrhage, as the case may be. More especially is it associated with the loss of fluid from the circulation, and until this loss has been made good the heart continues to labour under great disadvantages. It is therefore of primary importance to make good this loss as soon as possible. Two methods of administering fluids to the depleted body are available: (1) by means of the alimentary canal; (2) by intravenous or subcutaneous injections. When circumstances permit, the first-named channel of administration is of great value. Very large quantities of fluid may be administered by the mouth, and by means of forced drinks alone a diminished blood volume may be raised to the normal within a comparatively short period. Unfortunately in many cases of shock persistent vomiting prevents the administration of anything except a small amount of fluid by the mouth. In such cases rectal salines are of value. When, through the weak action of the sphincter, difficulty is experienced in ensuring the retention of such salines, it is advisable to employ the Murphy drip method.

Where the need of giving fluids is urgent, or where administration by the alimentary canal is impossible, recourse must be had to subcutaneous or intravenous salines. Of the two routes the intravenous is the more certain, owing to the fact that in cases of severe shock absorption from the subcutaneous tissue is liable to be retarded, or even absent. A great number of different transfusion fluids have been employed from time to time (normal and hypertonic salines, dextrose solutions, Ringer's fluid, etc.), but in the experience of most observers the particular formula selected does not appear to be of great importance. All of these varieties of transfusion fluid are equally liable to fail in maintaining the blood pressure when shock is severe. They filter through the blood-vessel walls and are lost

to the circulation. In the hope of overcoming this difficulty, Bayliss has advocated the use of a 6 per cent. solution of gum acacia in normal saline. The results obtained from this fluid, though promising in the laboratory, have been somewhat disappointing clinically. It is, however, certain that gum-saline remains longer in the circulation than saline alone.

*Transfusion of human blood.*—In cases of shock associated with hæmorrhage transfusion gives wonderful results. In cases of *pure* shock it is of doubtful value. The technique of transfusion has been so simplified that it is no longer a formidable undertaking. Direct methods by which an anastomosis was formed between the donor's artery and the recipient's vein have been abandoned in favour of the simpler indirect method. In this the blood is received

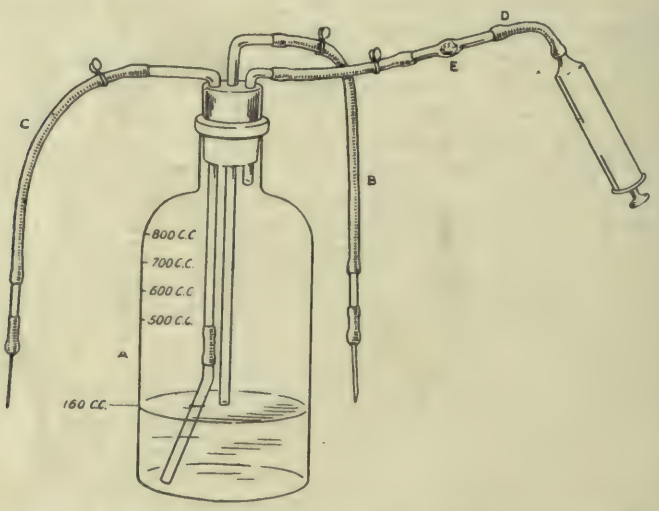



FIG. 32.—A. Bottle of one litre capacity containing 160 c.c. of isotonic sodium citrate.
B. Intake tube with needle (large calibre).
C. Tube through which blood is administered with needle. Note that the tube reaches the lowermost part of the bottle, so that no blood is wasted.
D. Pneumatic pump for producing either a negative or positive pressure according to whether blood is being drawn off or administered.
E. Glass connecting piece containing cotton wool to act as an air filter.
N.B.—The bottle must be gently agitated during the whole operation of drawing off blood so as to ensure proper mixing with the citrate.

into a vessel and from thence allowed to flow into the recipient's vein. Coagulation is prevented either by diluting the blood with an isotonic solution of sodium citrate (3·8 per cent.) or else by carefully coating the interior of the receiving vessel with melted paraffin. A useful apparatus for use with the citrate method is shown in Fig. 32. For 700 c.c. of blood 160 c.c. of the isotonic sodium citrate will be required. The blood from the donor's vein is first aspirated into the bottle through tube B, and then by reversing the pump and clipping tube B slowly injected through C into the vein of the recipient. Fig. 33 shows a Kimpton tube employed in the paraffin method. Here gravity alone is usually sufficient to ensure the flow of the blood into the recipient's vein. The interior of the vessel is carefully coated with melted paraffin to prevent coagulation.

Previously to the performance of transfusion the compatibility of the donor's and recipient's bloods should have been tested. Hæmolysis is an uncommon

but easily avoidable accident. If the patient's serum is found to cause clumping of the donor's corpuscles that particular donor is unsuitable.

**The scope of drugs in the treatment of shock.**—Of the numerous drugs that have been advocated at various times for the treatment of shock there are few that merit serious consideration. Morphia is one of the few. When shock results from the exhausting effect of pain, and it is imperative to obtain rest, morphia is of enormous value. In such cases it should be pushed until its full benefit is obtained, the slowing of the respiration rather than the size of the pupils being taken as the criterion of its action. Except in cases of temporary collapse, stimulants are useless, if not harmful. Pituitrin and suprarenal extract are equally unsuccessful in shock. Alkalis have been given with the idea of counteracting the acidosis which occurs in the later stages of shock. In cases associated with intractable vomiting a 2 per cent. solution of sodium bicarbonate is a useful alternative to an intravenous injection of normal saline.

FIG. 33.—Kimpton tube for the indirect paraffin method of transfusion. It is drawn out into a beak (*a*) sufficiently fine to allow of its entrance into the exposed vein of the donor, and subsequently of the recipient. The intravenous pressure of the donor is usually sufficient to ensure the filling of the vessel and gravity to promote its entry into the vein of the recipient, the intravenous pressure of the latter being low.

**Anæsthetics and operations in shock.**—A mixture of nitrous oxide and oxygen is by far the best anæsthetic for use when an operation is imperative. Ether, in spite of its temporary stimulative effect, is followed by a dangerous reaction. Spinal anæsthesia, although excellent in many cases, produces in others a marked fall in the blood pressure. This fall is temporary, but nevertheless very alarming.

The question of when to operate in shock is very difficult. If the patient's blood pressure is below 80 the risks from an anæsthetic and an operation are considerable. When the injury from which the patient is suffering is not very extensive the tendency should be in the direction of delay. When much laceration of tissue has occurred and there is risk of absorption of tissue products going on over an extensive area operation should be hastened. If immediate operation is the patient's only chance, and his condition is so grave that his capacity to withstand an anæsthetic is in doubt, transfusion should be performed *before* operation. In less serious cases transfusion is best undertaken during or at the end of the operation.

# Section III.

## DEFORMITIES.

Deformities are either congenital or acquired. Congenital deformities may be ascribed to a primary error of development or to intrauterine disease or pressure. Some so-called congenital deformities are really due to injury at birth. In many congenital deformities an hereditary or familial factor can be established.

Acquired deformities are due to injury or disease of the bones, joints, ligaments, muscles, or nerves, and also to contractions of the skin, subcutaneous and other areolar tissue. In many cases a double causation can be recognised, the actual deformity being produced by some mechanical strain acting upon tissues which have been affected by the pathological process. Upon the one hand we have perhaps destruction of bone by disease or softening and stretching of ligaments; upon the other we have the strain placed upon these structures by the weight of the body or of some part of it, or the effect of the unbalanced pull of certain muscles. It is important that this dual origin of a deformity should be recognised and the part taken by the two causative factors differentiated. Mechanical causes alone do not tend to produce severe deformities. To take an example, the weight of the body acting upon the growing bone at the epiphyseal regions of the tibia and femur at the knee commonly produces a slight degree of knock-knee. This is so common that probably 50 per cent. of children show it; it is slight and tends to recover spontaneously. Suppose, however, that the child suffers from rickets, a disease in which the newly-formed bone is too soft, then the same mechanical factor may give rise to a severe deformity.

### Congenital Deformities.

For generalised congenital deformities, monsters, etc., works upon obstetrics must be consulted. Regional congenital deformities may be grouped into the following general classes, but the deformities themselves vary greatly in individual cases. The more important deformities will be found further described under the *Deformities of Regions*.

**Asymmetry.**—A slight inequality upon the two sides is not unusual and of little importance; thus a difference in the length of the lower limbs amounting to $\frac{1}{4}$ or $\frac{1}{2}$ inch is common. More considerable asymmetry may be due to gigantism of one limb or to diminution in size of the other. Gigantism is most often due to a condition of diffuse lymphangioma or to overgrowth accompanying a diffuse nævoid condition. In either case the enlargement affects all the parts of the limb, the bones, muscles and other tissues all being larger than normal; the limb may be increased in length by as much as 2 or more inches. No treatment other than that to equalise the length of the two lower limbs by a suitable boot is possible.

A diminutive limb is often the result of paralysis—for example, in hemi-

plegia. Occasionally a diminutive limb co-exists with other deformities, such as webbing.

**Defect of a segment of a limb** may occur, the rest of the limb being normal: thus the whole femoral segment may be missing, the tibia articulating directly with the pelvis; or the affected segment may be shortened to a greater or less extent and may then fail to grow equally with the rest of the limb.

**Congenital constrictions** are not uncommon. They may occur around any part of a limb, or even around the trunk or neck. In many cases the distal part beyond the constriction is diminutive or rudimentary; it may be completely absent, forming the usual variety of congenital amputation. The constrictions consist of scar tissue, both in and under the skin. It is supposed that they are due to amniotic bands which have encircled the limb, cut off or diminished its blood supply, and so interfered with its proper growth. If such a constriction gives rise to any symptoms it may be dissected out. Most often all that is called for is re-amputation or trimming-up of the extremity, either for the sake of appearance or to enable an artificial limb to be worn.

FIG. 34.—Gigantism of left lower limb due to a diffuse lymphangioma and causing 2 inches lengthening.

**Addition to limbs** occurs only in the hands and feet in the form of supernumerary digits. Occasionally these are perfect: more often they are rudimentary and of no use; they should then be amputated. There is a strong hereditary factor in the occurrence of supernumerary digits.

**Webbing** between the fingers or toes is not uncommon. It occurs in two principal varieties, close and loose. In the former there is no interval between the fingers, and the bones themselves may even be fused; in these cases separation may be difficult or impossible. In the loose variety there is a broad web, the fingers are usually perfect, and separation is comparatively easy.

Webbing occasionally occurs across the flexor surfaces of joints such as the elbow and knee or across the axilla. In such cases the malformation may be of the skin only, or there may be an incomplete segmentation of the limb, so that the muscles from the upper arm or thigh pass straight on without differentiation into those of the forearm or leg.

**A diminution in the number of digits** may occur apart from congenital amputations; the most frequent variety is that known as the "*lobster claw*"

deformity, in which the hand or foot is cleft down to the region of the metacarpals or metatarsals, each half bearing one or two large digits. This deformity is hereditary.

**Congenital fractures** (so called) are really instances of defective growth of certain segments of the limbs : the usual sites are in the forearm and in the leg ; they will be found described as Radial Club Hand and Congenital Defect of the Fibula.

**Congenital dislocations** occur in the hip and possibly in the shoulder ; they are described under *Deformities of Regions* (p. 248).

Fig. 35.—Congenital constrictions around the trunk and around several of the toes.

Other congenital deformities are due to absence of or variation in the size or shape of bones (absence of the clavicle or of half a vertebra), the presence of additional bones (cervical rib), absence of muscles, and contraction of muscles and ligaments (club foot). They will be found under *Deformities of Regions.*

## General Defects of Stature or Physique.

In many cases general overgrowth (*gigantism*) and undergrowth (*dwarfism*) are due to disease. It is convenient to include together the known diseases which produce these defects as well as those which give rise to retarded development (*infantilism*) and to premature senility (*progeria*).

**Acromegaly.** — Acromegaly is an acquired form of partial gigantism in which the face, especially the lower jaw, and the hands and feet are most enlarged. It arises usually in young adults, and is rather more common in women than in men. There is a slowly-progressive enlargement of the lower part of the face and of the hands and feet, and to a less extent of the whole of the body. This enlargement affects all structures ; the skin is thick and coarse, the subcutaneous tissue thickened, the muscles hypertrophied, and the bones themselves enlarged. A very characteristic facial expression is produced. The lower jaw which is much affected is prominent, the skin of the face hangs in folds, the lips are everted and thick, the tongue is large, the eyelids may be much thickened, and the ears greatly hypertrophied. As the disease progresses the whole skeleton is affected. An evident kyphosis arises, and all the bones may become enlarged. This alteration in the bones is due to actual interstitial growth, the bones growing in length as well as in thickness. Such growth in the lower jaw produces an interesting phenomenon

—the vertical ramus often increases so much in length that the posterior teeth of the two jaws are prevented from meeting. Other symptoms are often present. There is a general muscular weakness: in women there is often amenorrhœa; in men impotence: glycosuria is occasionally present.

In many cases in the late stages ocular palsies and optic neuritis develop.

Acromegaly may occur in a benign or in a malignant form. In the former the disease may exist for as long as fifty years; in the latter it may be fatal in three or four years. In the rapidly-progressive form symptoms of cerebral tumour occur, and the patient may die as the result of these.

*Pathology.*—Marie in 1889 associated acromegaly with the existence of a new growth of the pituitary gland. It is, however, only comparatively recently that a more accurate classification of the tumours of this gland has made it clear that this disease is due to a hypertrophy of the anterior lobe of the pituitary, or to an adenoma of the chromophile cells of that part. Other tumours of the pituitary are not associated with acromegalic symptoms. Acromegaly then is due to hyperpituitarism, *i.e.*, to an excessive functioning of the anterior lobe of the gland. In most advanced cases an increase in the size of the pituitary fossa can be demonstrated in a skiagraph. The occasional cases of acromegaly in which no enlargement of the pituitary has been found after death may be explained either as instances of physiological hypertrophy in which there was no naked-eye enlargement—but microscopical evidences of excessive function would have been found if looked for—or as cases of enlarged pituitary remnant in the roof of the pharynx, of which at least one has been described.

FIG. 36.—Supernumerary digit upon the outer side of the foot.

*Treatment.*—No medicinal treatment has any effect upon acromegaly. Now that the pathology is known, the rational treatment is evidently to remove the enlarged anterior lobe of the pituitary gland, and this has been successfully accomplished many times. The result has been to stay the progress of the disease, to remove the cerebral symptoms, and even to cause to a certain extent a recession of the characteristic appearances of the disease. The operation is usually carried out through the nose and through the sphenoidal sinus; it is a difficult and dangerous one, but should be advised in all rapidly-progressive cases, and in all cases associated with cerebral symptoms.

**Gigantism.**—A considerable proportion (according to Sternberg 40 per cent.) of giants suffer from acromegaly: and possibly others, who have no signs of acromegaly, suffer nevertheless from hyperpituitarism. Acromegaly in which, as already mentioned, there is interstitial overgrowth of the bones,

if it arises before growth is complete, causes such overgrowth of the skeleton as to produce a giant. But probably there is also a certain proportion of giants who are in normal health.

**Froelich's syndrome.**—This is a form of defective development, particularly of sexual development, associated with adiposity. It usually arises during growth: if before puberty, sexual development does not occur; if after puberty, there is a reversion to the infantile type, with a loss of the secondary sexual characters. There may be extreme adiposity; the skin resembles that in myxœdema, and there may be polyuria. Very often these symptoms are associated with failure of vision, colour vision characteristically failing first, and with other symptoms of cerebral tumour. Froelich's symptoms are probably due to a failure of function of the pars intermedia or posterior lobe of the pituitary gland. Removal of the gland has been successfully carried out in these cases.

It is now clear that disease of the pituitary gland does not necessarily give rise to a single complete symptom complex. In hyperpituitarism there are some or all of the symptoms of acromegaly; in hypopituitarism there are symptoms of infantilism approximating to the Froelich type, or to some similar type. But in early hyperpituitarism before growth is complete there may be gigantism; in acromegaly or gigantism after a preliminary period of hyperpituitarism there may be a subsequent failure of action of the pituitary; so that with some of the signs of acromegaly there are more recent symptoms which fall into the Froelich type. In addition the visual and cerebral signs and symptoms may occur in cases of any class when there is a tumour in the pituitary region of sufficient size or of such conformation as to press upon or involve the neighbouring structures.

## Dwarfs.

Dwarfs may occasionally be perfect in their proportions and in their mental and sexual development; they are then called true dwarfs. But most often dwarfing is due to disease. The majority of dwarfs fall into the following classes:—

**Achondroplasia or chondrodystrophia.**—In achondroplasia the defect in growth is of the long bones. In a typical case the trunk is of full size, but the limbs unduly short. The head is characteristic in shape; the lower part of the face is natural; the nose is, however, depressed at its bridge, and the forehead bulges forward above it. The skull appears to be of excessive size, but on measurement it will be found that this appearance is deceptive. The basis cranii is in fact shortened in its antero-posterior diameter, so that the distance from the root of the nose to the occiput is shorter than it should be; consequently the calvarium bulges out above and appears large—it is, in fact, broad and high, but shorter than natural. The trunk is thick-set and often very muscular; the spine and chest are well formed. The long bones of the limbs are all short, so that the hands hang at about the level of the hips instead of half-way down the thighs. The hands and feet are short and broad, and the former show a very characteristic deformity. On account of the shortening of the metacarpal bones and phalanges, the soft parts being of their usual thickness, only the first phalanges of the fingers lie in contact with each other in the extended hand; the second and third phalanges diverge from each other.

It must not be thought, however, that this typical picture is invariably found in achondroplasia; all grades of severity occur in the disease. In the most extreme cases, which are often still-born, the skull is extremely shortened

and the limbs may be so short as to be almost suppressed. At the other extreme lie cases in which the limbs are short but there are no other abnormalities. Between these, cases occur which are typical; others in which with the characteristic deformity of the limbs the skull is normal; others in which, with affection of the skull and limbs, the hands fail to show the usual characteristic. And in fact cases occur in which it is difficult to say whether a shortness of stature, in which the defect is chiefly of the long bones, should or should not be attributed to achondroplasia.

In some cases of the disease there is much thickening of the bones in the region of the epiphyseal lines; in others this is absent; these two classes have by some been made into two separate conditions — chondrodystrophia hyperplastica, and hypoplastica. There seems, however, to be no real basis for this distinction.

Certain of the long bones are often curved in achondroplasia. The commonest deformities are bow-leg, chiefly due to bowing of the tibia—although the femur may be bowed also—and knock-knee, due to an obliquity of the lower end of the femur. Bow-leg is by far the more common, so that it might almost be considered to be the rule for children the subject of achondroplasia to show it.

The patients are usually well developed as to their muscles; mental and sexual development are normal.

Skiagraphs of the long bones show no abnormality in the shaft, if the shortness and curvature be excepted. The epiphyseal nuclei are, however, smaller than they should be, and are overlapped at their edges by the somewhat hypertrophied extremities of the diaphyses; the epiphyseal lines are present during the usual period, and there is not, as was formerly thought, an early synostosis between the diaphysis and epiphysis.

FIG. 37.—Achondroplasia.

Nothing is known of the pathology of the condition beyond the fact that there is a defective growth of those bones which are formed in cartilage. The epiphyseal lines, as already stated, are present, but in some cases at least there is an ingrowth into the conjugal cartilage of fibrous tissue extending from the periosteum, so that this might interfere with growth. In the basis cranii an

absence of the cartilage normally found between the basisphenoid and basi-occipital bones is sometimes, but by no means always, found.

There is no evidence to connect achondroplasia with defective activity of any glandular or other organ. A theory of the origin of the disease has been suggested by Jansen. He claims that such a defect of growth could be originated by compression of the fœtus, due to an insufficiency of amniotic fluid, during the third to sixth weeks of intrauterine life—that is, at the period at which the limb buds are being formed and the rudimentary cartilage laid down; pressure upon the head in the flexed position in which it lies at this stage shortens its antero-posterior diameter; pressure upon the posterior extremity of the embryo produces a kyphosis in the dorso-lumbar region, which Jansen has pointed out as being frequent if not invariable. This theory, whilst it must remain at present a pure theory, is the only reasonable suggestion at present before us.

Fig. 38.—Rickety dwarf with scoliosis and severe curvature of the femora and tibiæ.

Little need be said about the treatment of achondroplasia. Nothing can be done to improve the growth, but osteotomies may be carried out where necessary to correct curvatures of the bones. These are quite safe, and good union occurs.

**Cretinism** is that form of dwarfing which results from absence or loss of function of the thyroid gland. It differs from achondroplasia in that mental and sexual development are deficient. The child is short, fat, and flabby, and the body and limbs are equally undeveloped. The muscles are poor, the skin dry and coarse, and the hair thin. The deformities of the hands and of the head so characteristic of achondroplasia do not occur. The thyroid gland may be absent, or it may be present, and even enlarged but functionless. A similar condition may result from atrophy of the gland after a specific fever during childhood or after extirpation of the gland by operation.

The administration of thyroid extract in regular doses will always cause improvement; but whereas in a few cases the child becomes practically normal, in most cases the lack of development, particularly of mental development, persists in a milder degree. For further information upon cretinism, works upon medicine must be consulted.

**The rickety dwarf** presents the features of the most severe form of rickets. The head is high and its antero-posterior diameter is long; the spine may be severely curved; the femora are bowed forwards and outwards; the tibiæ much curved. Mental development is backward, and sexual development may be delayed.

Osteogenesis imperfecta, rachitic osteomalacia, and true osteomalacia also result in great dwarfing.

Apparent dwarfs are produced by severe spinal curvature, due either to scoliosis or to spinal caries; the trunk is greatly shortened by the curvature, whilst the limbs may be of normal length.

**Infantilism.**—By infantilism is meant a preservation of the characteristics of childhood, particularly sexual characteristics, into the period of adolescence or of adult life. Certain dwarfs, for example cretins, are infantile in this sense, others are not. But in addition many other children fail to grow at the proper rate and to develop their sexual characters. These cases of infantilism are divisible into several classes. In all there is some general defect of metabolism; in some this is associated with defect in the action of the thyroid gland, in others with defect in the kidneys, in others with defect in the pituitary, and others suffer from some chronic intestinal disturbance. For a consideration of infantilism in general, works upon medicine must be consulted. In certain forms, more particularly in the renal form, changes in the bones simulating those of rickets may occur and deformities may arise; for this reason the diagnosis of these conditions from ordinary rickets is important. This will be further alluded to in the discussion of rickets.

**Progeria.**—In occasional rare instances the phenomena of infantilism—that is, delay in the development of the adult characterisitics—have been combined with or followed by an early onset of senile changes, so that the child presents the appearances of old age. To this condition the name of *progeria* has been given.

## Disease of the Bones producing Deformity.

General or local disease of the bones may produce deformity in several ways. In the first place there may be a primary defect in the bone originally laid down, so that it bends or breaks with ease; this is the pathology of osteogenesis imperfecta, and probably of fragilitas ossium. In the second place there may be a disproportion between the formation of bone by osteoblasts and its destruction by osteoclasts or other normal means, that is, a variation in the normal process of ossification. In the third place there may be an actual process of solution of the mineral matter of the bone, the framework being left intact (*halisteresis*). The latter change is an unusual one, but is the essential pathological process in true osteomalacia.

Of these three the second is by far the most important. So that it is evident that the mode of growth of bone must have an important bearing upon the production of deformities and upon their prognosis.

The first ossification of a bone occurs after an irruption of a vascular tissue containing osteoblasts from the surface into the substance of the original cartilage of the diaphysis; this occurs about the seventh week of intrauterine life. Later, at times varying in the different bones, a similar patch or patches of ossification occur in the epiphyses; so that after birth in each long bone there are as a rule at least three centres of ossification—one in the shaft and one or more at each end, the latter being separated from the main mass in the shaft by two transverse lines of cartilage, the epiphyseal cartilages. The subsequent growth of bone in length and thickness occurs as the result of the activity of the osteoblasts of the bone and periosteum and of these epiphyseal cartilages. The osteoblasts exist in three situations—on the surface, forming the deepest layer of the periosteum, in the interior of the medulla, forming the endosteum, and lining every space in the cancellous bone and every Haversian canal in the compact bone. In the last two situations, the medulla and the cancellous and Haversian spaces, there also exist numerous giant cells (*osteoclasts*), which possess the power of absorbing bone and cartilage. These cells throughout the period of growth are in constant activity; the osteoblasts of the periosteum lay down upon the surface new layers of bone, increasing

the thickness of the shaft, those of the cancellous spaces and Haversian canals are constantly adding to the bone on the interior of these spaces, whilst the osteoclasts are engaged in causing the absorption of bone in these situations. As a result of these processes the structure of a growing bone is being constantly altered and adapted to its function; so that it is strengthened where necessary, lightened by absorption where possible. The resulting adult structure is thus attained, and this structure, although based upon an original plan, is to some extent dependent upon the various strains to which the bone has been subjected during its period of growth, increased pressure being met by the formation of stronger weight-bearing lamellæ, lessened pressure by a corresponding lightness of the bone. We thus find that the bones of a limb that has not borne weight are excessively light, the lamellæ being very thin. But although these changes are most characteristic of the growing period, they are not confined to that period; the power of adaptation to altered pressure conditions is inherent in the bones and persists throughout life. Even in the adult any alteration of pressure conditions is met in time by an alteration in the architecture of the bone, brought about as the result of the activity of the osteoclasts and osteoblasts. So that if the alignment of a long bone is altered by malunion of a fracture the bone in time undergoes an alteration; it is strengthened by compact layers where necessary, lightened by absorption where compact tissue is no longer required. This power of adaptability in bone is of the greatest importance in the natural improvement of deformities. The observation of these facts we owe to Julius Wolff, and their statement is known as Wolff's law.

Growth in length of the bones occurs in the main at their epiphyseal ends. In outline the process is as follows. The cells of the intermediate cartilage are constantly dividing, the new cartilage cells produced being enclosed in a matrix and pushed towards the bone of the shaft. At the same time the cancellous spaces of the neighbouring part of the shaft contain highly-vascular tissue, including osteoblasts and osteoclasts; at the junction of the cartilage and bone the intermediate layer of cartilage matrix is absorbed, probably as the result of the action of the osteoclasts, and this medullary tissue invades the cartilage spaces. Here the cartilage is promptly absorbed and bone laid down, so that the newly-formed cartilage pushed towards the bone is only very temporary; it is soon invaded and replaced by bone. Two processes are thus occurring side by side—the growth of cartilage and the invasion and replacement of this cartilage by bone. It is important that in considering the part taken by the epiphyseal cartilage in this growth we should not forget the equally important share taken by the contents of the medullary spaces.

But bone grows in length also by another method. As already mentioned, bone is constantly being deposited by the osteoblasts which line the cancellous and Haversian spaces. The latter are not strictly longitudinal in direction; they extend as a rule obliquely for some distance along the length of the bone, and then end either by opening into another space or by opening upon the surface of the bone. So that the osteoblasts lying in their interior, in adding to the thickness of the wall of the spaces, may in some cases where the space is running obliquely be adding to the length of the bone; and although the addition thus made in each Haversian space is very small, the total addition to the length of the bone is not negligible. Similarly a small addition to the length of a bone may result from growth in the interior of the cancellous spaces. This mode of growth is called interstitial growth; whilst it is of small importance in normal growth, it is a factor in the production of certain deformities in inflammatory diseases of bone.

Interference with the growth of a bone most often arises as the result of some lesion of the newly-formed bone quite close to the epiphyseal line. This area is a weak one, for at it the cartilage matrix found in the actual epiphyseal cartilage has to some extent undergone absorption, whilst the formation of bone is as yet small; in addition the area is very vascular, and it is thought that the fact that its arteries are end arteries renders it more liable to septic infection. At any rate, this is the region through which the injuries known as separations of the epiphyses occur, and this is the region so often infected in acute septic epiphysitis. An injury to this region or an infection of this region is not invariably followed by a diminution in the subsequent growth of the bone, and is seldom followed by a complete arrest of that growth. For practical purposes injury and sepsis may be considered together, for in each case the result upon growth probably depends upon the production of a scar in the bone. Such a scar, consisting of a new formation of fibrous and osseous tissue, has the effect of delaying or preventing the ingrowth of the tissue of the medullary spaces into the growing cartilage, so that in experimental separation of the epiphyses a wider area of cartilage than normal is found in this region; ossification and growth are thus diminished or delayed, and the blame for this is to be laid rather upon the bone than upon the cartilage. If such diminution of growth occurs equally across the epiphyseal line, a simple shortening of the bone will result; if, however, it is unequal, being greater at one side than at the other, then by unequal growth upon its two sides a deformity of the bone will result. A similar deformity may arise when the growth of one of a pair of bones such as the radius and ulna is affected; in such a case, however, it is not unusual to find that the bones continue to grow straight but that their ends separate.

Another class of lesion may also affect the growth of the long bones at the epiphyseal lines. A chronic inflammation in the neighbourhood of an epiphysis by causing a long-continued hyperæmia in this region may increase the actual growth thus occurring, so that such a bone grows more than its healthy fellow. The most frequent example seen of this is in the result of tuberculous osteitis in the neighbourhood of the knee-joint, where two important epiphyses are situated. It is the rule in tuberculous osteitis in this region, which has been unaccompanied by destruction of bone, to find that the affected limb is longer than the other by as much as ½ to 1 inch.

The third way in which the growth in length of a bone is affected depends upon the occurrence of interstitial growth. A chronic inflammation in the shaft of a bone almost regularly gives rise to a slight increase in length, and although this is seen most evidently when the affected bone is a young one, it also occurs in bones of all ages, even in osteitis deformans, a disease chiefly of advanced age. The other conditions in which this interstitial overgrowth is frequently seen are chronic septic or tuberculous infection of the shaft and syphilitic osteoperiostitis. In the latter condition, in congenital syphilis affecting the tibia, an interesting phenomenon occurs. The anterior part of the bone is chiefly affected; consequently the anterior part of the bone grows more than the posterior part, and an anterior convexity in the shaft is produced. A similar inequality in the interstitial increase in the bones is probably a cause of the deformities of osteitis deformans.

Many of the facts as to the effect of injuries and inflammatory lesions upon the growth of bone were worked out by Humphry, to whom we owe a statement often alluded to as Humphry's law. This is that a lesion of the epiphyseal end of a bone may produce deficient growth, a lesion of the shaft may produce overgrowth. This, it will now be seen, is an incomplete statement.

It may be completed as follows. An injury or acute inflammatory lesion of the epiphyseal end of the shaft of a long bone may give rise to diminution in growth at the neighbouring epiphysis; a chronic inflammatory lesion of the epiphyseal end of the shaft, or of the epiphysis itself, may give rise to increased

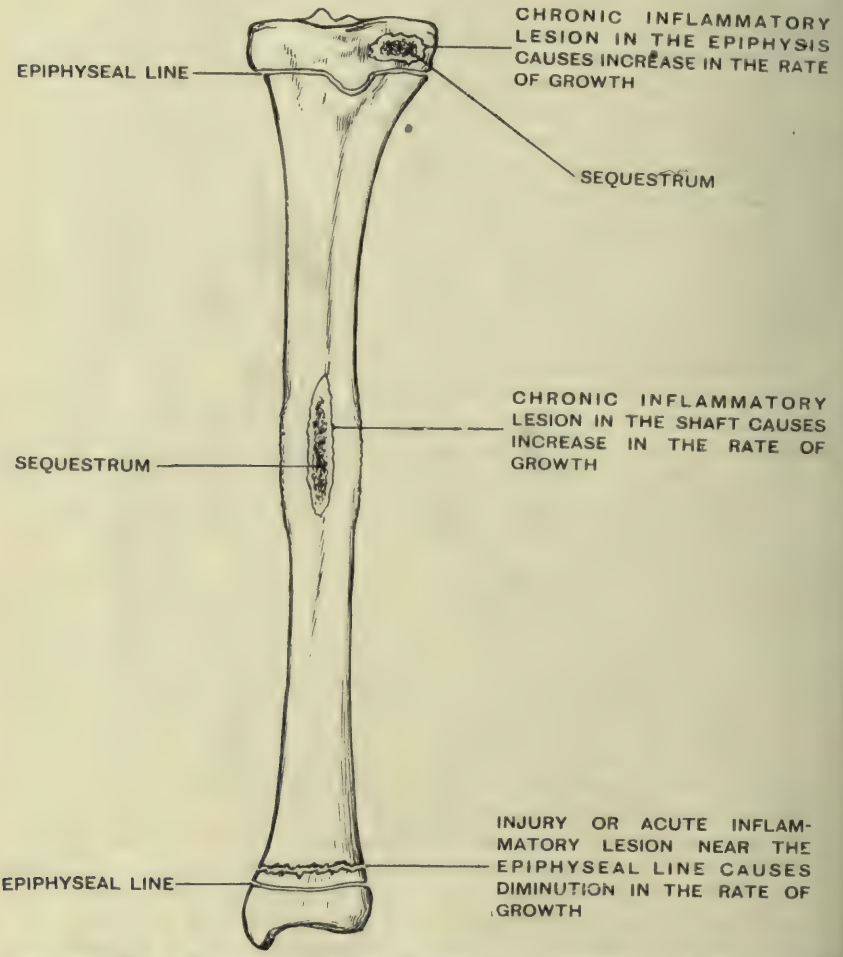

CHRONIC INFLAMMATORY LESION IN THE EPIPHYSIS CAUSES INCREASE IN THE RATE OF GROWTH
EPIPHYSEAL LINE
SEQUESTRUM
CHRONIC INFLAMMATORY LESION IN THE SHAFT CAUSES INCREASE IN THE RATE OF GROWTH
SEQUESTRUM
INJURY OR ACUTE INFLAMMATORY LESION NEAR THE EPIPHYSEAL LINE CAUSES DIMINUTION IN THE RATE OF GROWTH
EPIPHYSEAL LINE

FIG. 39.—Diagram illustrating the effect of injuries and inflammatory lesions upon the growth of bone.

growth at the neighbouring epiphysis; a chronic inflammatory lesion of the shaft may give rise to overgrowth of the bone by increasing interstitial growth.

## General Diseases of the Bones producing Distortion.

**Rickets.**—Rickets is a general constitutional disease, associated with defective nutrition, and characterised by a softening and tendency to distortion of the long bones.

It is extremely common throughout the world, being more frequent and more severe in large cities, and specially in slums; but it is by no means limited to town dwellers, many severe cases being found in country districts. In Germany, where it is frequent and severe, it is commonly known as the

*English disease*, not because of a supposed greater frequency in England, but because it was first recognised and described by an English physician, Glisson. Rickets is essentially a disease of infants; it usually arises soon after weaning, that is, at the age of six months to one year. In the large majority of cases its period of activity extends only to the end of the second year of life, but it may remain progressive until a much later period, a point which will be further alluded to in discussing the existence of late rickets. A family incidence of the disease is common; this can be explained sufficiently by the fact that similar surroundings and diet may produce the same nutritional disorder in all the members of a family, without any necessity to suppose a liability of particular families to the disease.

*Symptoms.*—The onset of rickets is insidious; most often the disease is discovered in a child examined for some other possibly-associated condition, or else advice is sought on account of the bone deformities, which constitute evidence that the disease has already been progressive for a considerable time. In the early stages there are often digestive disturbances, perhaps associated with a little fever, and the child is irritable. Teething is late; the child walks late or, if he has walked before the disease commences, shows a disinclination to get upon his feet; he is pale and flabby and the muscles are soft. In severe cases there may be a pseudo-paralysis, partly due to weakness, partly to a disinclination to use limbs which are painful. There is diffuse sweating, particularly of the head.

The most characteristic changes are those occurring in the bones. The first change to be noted is an enlargement of the epiphyseal regions of the long bones, best noted at the wrists and at the costo-chondral junctions (which represent the epiphyseal ends of the ribs). Immediately after this deformities arise as the result of moulding of the soft bones by pressure. These deformities, although they occur in definite typical forms, vary greatly in each case. Each deformity, being due to moulding of the affected bone as the result of pressure, must have a double cause—first, the pathological process, which leaves it soft, and, secondly, the particular mechanical force, which bends it into its abnormal form; so that it is necessary to consider what forces produce the more frequent deformities. In the first place it will be noted that the ends of the bones near the growing epiphyseal lines are apt to become more curved than are the central parts of the shafts. This can be explained by the pathology, for whilst in all cases of the disease the formation of new bone at the epiphyseal regions is defective, it is only in the most extreme cases that there is any considerable absorption of the bone already formed in the shaft.

Take the regions *seriatim*. In the skull the extension of the bone at its growing margins is slow, so that the fontanelles close late, and the frontal and parietal eminences, indicating the first areas of bone formation, become prominent. In a well-marked case of rickets the head has a very characteristic appearance. The forehead is high and square; the frontal eminences are prominent; the antero-posterior diameter of the skull is long. The fontanelles close late, but after these have closed and all active disease has ceased, the characteristic shape of the head remains and may permanently mark the patient as a subject of former rickets.

The spine may bend forwards at about the level of the dorso-lumbar junction so that a low kyphosis is produced, or it may bend laterally, most often to the left at the dorso-lumbar junction, or to the right in the upper dorsal region. These curves are to be explained as the result of sitting postures, particularly as the result of sitting upon the left arm of the nurse.

The chest becomes deformed, more particularly when there is an associated respiratory obstruction, such as the supervention of an attack of laryngitis, or when adenoids are present. In these conditions there is a tendency for the unsupported parts of the chest wall to sink in, especially if these are parts at which the bone is soft. Consequently a lateral sulcus appears on either side of the sternum, due to the sinking in of the newly-formed part of the ribs near the epiphyseal lines, leaving the sternum between prominent (*keeled sternum*). As a result of this also the enlargement of the costo-chondral junction, originally equally marked upon the external and internal sides of the chest, becomes masked externally and increased internally. The second line along which the chest is apt to sink in is at the level of the upper margin of the liver. Below this it has the support of this solid organ, which is lacking above. The transverse sulcus thus produced is named Harrison's sulcus.

Fig. 40.—Rickety child with severe bowing of tibiæ.

In the upper limbs any considerable deformity of the bones is the exception. When a child with bad rickets crawls much, however, an antero-external convexity of the humerus and a postero-external curvature of the bones of the forearm may be produced. If the bones of the forearm become much curved a fixed pronation deformity may arise, supination becoming impossible.

In the lower limb the deformities most frequently seen are those which result from pressure in the sitting position, particularly in the crossed-legged sitting posture. An antero-external convexity of the femur and a similar curve in the tibia are thus produced. The curve in the tibia is the most frequent and the most characteristic bone curve of rickets and requires a little further description. Most commonly there is a convexity outwards occurring chiefly near the lower end of the bone; less frequently the curve is in the same situation but convex directly forwards; in other cases the curve is intermediate between these and is convex antero-externally. It is important to note that these curves are originated in the sitting position, and not in standing. In any rickety child with the ordinary form of bowing of the tibiæ this can be easily demonstrated by placing him in the cross-

legged position; it will then be seen that the curved legs fit into one another as if they had been specially shaped for the purpose. A second important point is that although the curve is characteristically near the lower end of the bone, this is not invariably the case. In severe cases there may be a curve throughout the shaft; such a curve is usually convex outward.

The standing posture must, however, not be ignored as a cause of rickety deformities of the lower limbs. In a standing child, if outward bowing of the femur and tibia already exist, it will tend to increase as the result of the pressure of the weight of the body, but if the limbs have up to this point been straight a different deformity will be produced. In the standing posture the strain is greater upon the inner side of the knee than upon the outer; there is already a slight angle, opening outwards between the axis of the shaft of the femur and that of the tibia, and the tendency of the pressure will be to increase this angle and to produce knock-knee. It often happens that the forces concerned in the production of rickety deformities in the lower limbs are more complicated than those simply described above, and combined and complicated deformities are therefore not uncommon. But it may be accepted as a general principle that bow-leg is a deformity of the sitting posture, knock-knee a deformity of the standing posture.

FIG. 41.—The same child seated cross-legged, showing that in this position the curved legs fit into each other.

In the feet rickets produces a deformity as the result of the associated weakness of the muscles. The arch of the foot is normally developed in the child as the result of muscular action as soon as the erect position is assumed. In rickets this development may be delayed, so that flat-foot results.

*Pathology.*—The characteristic changes in rickets occur in the bones. It is uncertain to what extent the other changes found, such as the enlargement of the liver and spleen, are accidental and due to associated diseases. In the epiphyseal lines the area of cartilage is increased in both directions, so that the epiphyseal region of the bone is enlarged, and there is also a greater thickness of cartilage between the epiphysis and the diaphysis. The line at which ossification is proceeding is irregular, and instead of forming a transverse line in a section it is concave towards the epiphyseal cartilage—in fact,

the end of the diaphysis is cup-shaped. The recently-formed bone at the margin is more vascular than normal, is soft, and may contain islands of cartilage of sufficient size to be obvious to the naked eye. The periosteum of the long bones is vascular, strips easily, and the bone beneath is soft. In severe cases the compact bone of the shaft itself may be softened and may even cut with a knife.

Microscopically, at the epiphyseal regions it is seen that the cartilage cells are dividing irregularly, so that instead of forming even parallel rows lying in the direction of the long axis of the shaft of the bone a complicated mass of cartilage columns is formed. Each column contains several cells abreast, instead of the single row normally found. This is apparently due to the formation by division of abundant cells without a sufficient amount of supporting matrix around, so that the cells become crowded and the columns consequently widened. This widening of the cartilage columns is the cause of the external enlargement of the epiphyseal regions. The cartilage cells are normally invaded at the level of ossification by vascular loops from the medullary spaces of the bone, bearing osteoclasts and osteoblasts. These should carry on a regular process of absorption of the cartilage and formation of bone instead. In the rickety bone this process is delayed and irregular. Hence on account of the delay in the absorption of the cartilage the epiphyseal line is unduly broad, and on account of the delay in the formation of new bone the neighbouring bone is soft. Similar changes occur under the periosteum of the shaft, so that bone is formed slowly and is imperfectly ossified. In severe cases similar changes occur throughout the bone, for in the rapidly-growing bone of the infant reconstructive changes are constantly occurring; each portion formed is only temporary, and as growth takes place it must be absorbed and replaced by new. In rickets the whole of these changes in the bones may be affected.

The nature of these changes is uncertain. Most probably they must be looked upon as inflammatory. Although they are characteristic of rickets and may be used as a test for the activity of the disease, they are not pathognomonic of rickets. Similar changes in the epiphyseal regions have been demonstrated after injury, and similar changes also occur in certain non-rickety types of infantilism, and even produce exactly similar bone deformities.

*Skiagraphy.*—As already mentioned, the most characteristic feature in rickets consists in the changes in the epiphyseal regions of the long bones. These changes are evidenced by the external enlargement of the epiphyses, and subsidence of these to their natural size is evidence that active rickety changes in the bones are no longer occurring. But this subsidence occurs slowly, and there may still be external enlargement of the epiphyses at the wrists weeks or months after the active disease is cured. A more accurate estimate of the activity of the disease may be found by examining the epiphyseal lines of the wrist in skiagraphs. In a skiagraph of a normal wrist the epiphyseal line of the radius is straight, transverse and narrow; in active rickets the bone is thickened, the end of the diaphysis cup-shaped and irregular, and the area of translucent cartilage may measure $\frac{1}{2}$ to 1 inch in section. As soon as active rickets has ceased the appearances in the epiphyseal ends of the bone return to the normal, the cartilage first becoming reduced to the normal width, the end of the diaphysis becoming straight, and finally the external enlargement disappearing. The appearances in a skiagraph of the epiphyses at the wrist thus form the best means of estimating whether the disease is, or is not, active and progressive.

*Diagnosis.*—The diagnosis of rickets in young children is not likely to give

rise to difficulty when well-marked bone changes are present. It must be remembered, however, that extreme muscular weakness, giving rise to such conditions as kyphosis and flat-foot, may exist with very little bone deformity. In doubtful cases the skiagraphy of the wrists will assist.

*Causation.*—The one certain fact concerning the causation of rickets is that it is a disease of metabolism and that one factor in its production is an excess of carbo-hydrates and a deficiency of fat and proteid in the food. Feeding upon patent foods rich in carbohydrates and upon condensed milks deficient in fat and albumen is a potent cause: in rather older children a diet consisting largely of potatoes is frequently to blame.

It is suggested, largely on Mellanby's experimental investigations, that rickets is a disease that results from a deficiency in the food of an accessory food factor, which is present in fresh animal fat, and is named "fat-soluble A." This opinion is, however, not universally accepted. Mellanby himself agrees that more of this anti-rachitic factor is required when the food is rich in carbohydrate, and less when the diet contains abundance of proteid. Other factors in the production of the disease are general unhygienic surroundings, deficiency of air, light, exercise, etc.

FIG. 42.—Skiagraph of the wrist of a child, aged 4, with active rickets. The epiphyses of the radius and ulna show characteristic changes, and only two of the carpal bones are ossified.

*Treatment.*—Two separate questions must be considered under treatment—(1) the general treatment of the disease, and (2) the treatment of the bone deformities.

The cure of the active disease depends on securing a proper diet. For a child of the usual age, that is, one to two years, plenty of milk, fresh and unboiled, a little fresh meat, preferably raw, meat juice, gravy, bacon fat, an egg, milk puddings, fresh vegetables and fruit may be given. Potatoes, biscuits, and cakes must be forbidden and the parents warned not to make bread and butter the staple diet. The meals must be given at regular times and all food betweenwhiles forbidden. The child should be in the fresh air as

much as possible. Such a proper diet with fair hygienic surroundings will cure active rickets in an infant in at most three months—that is, at the end of three months the characteristic signs will no longer be visible in skiagraphs of the epiphyses.

In theory the best method of preventing the progress of the bone deformities of rickets would be to keep the child recumbent until the disease is cured; acting upon this principle it is the custom of some to keep a rickety child off its feet by the application of splints or some similar method for a prolonged period. But the value of this as a preventive of deformities must be balanced against the harm done to the general nutrition, and on the whole rickety children do best if allowed complete freedom from all restraint. The increase likely to occur in such deformities as bow-leg and knock-knee during the short period required to cure infantile rickets by hygienic means is negligible.

When the spine is affected and has become curved, however, it is necessary to keep the child recumbent, or at least to apply a support which will maintain the straight position; for a spinal curve is a serious deformity, difficult to correct, and tending to progress as a result of mechanical causes after the rickets is cured. The best method of securing recumbency is by fixation upon a plaster bed.

Splints may be used in a different way as a preventive of the increase of rickety deformities. They may be applied to the concave side of a curve—*e.g.*, to the inner side of the leg for bow-leg, to the outer side for knock-knee—and an attempt made to pull the limb towards the splint and so straighten it, the splint reaching only as far as the ground and allowing walking. This method is often useful in treating a child with knock-knee. The deformities of the lower limbs in rickets tend to improve spontaneously and rapidly as growth takes place, and in the majority of cases they require no local treatment whatever. As a rule operative interference to correct deformity is inadvisable before the age of four years. At that age bowing of the tibia, if not rapidly improving, should be corrected by osteoclasis; knock-knee may be left a little longer, for here it is not advisable to attempt to straighten the limb by breaking, and an osteotomy can be performed just as easily and as satisfactorily at a later age. More details of the treatment of rickety deformities will be found under the several deformities themselves.

*Continued, recrudescent, late or adolescent rickets.*—The question of the occurrence of a *late rickets* has given rise to considerable controversy. The facts appear to be as follows. Although the large majority of cases of rickets are cured by the end of the second year, yet in certain children, usually as the result of neglect, the disease remains active, and the characteristic bone changes continue until a considerably later age. Such continuation up to the age of five is by no means uncommon; after that age it becomes progressively more rare, although cases are known in which the bone changes of active rickets, and also the general symptoms of the disease, have continued throughout the period of adolescence; such cases may be termed *continued rickets*. In other cases the activity of the disease has been interrupted by a period of apparent cure, during which the epiphyseal changes have disappeared, there being, however, a subsequent recrudescence of the disease, perhaps as a result of the recurrence of some unhygienic condition, and the bone changes again arising; such cases may be grouped as *recrudescent rickets*. In a third group of cases there is apparently an onset of rickets, with its general symptoms and its characteristic bone changes, at a late period of childhood or during adolescence; such cases are called *late* or *adolescent rickets*. But as many cases of infantile rickets go unrecognised, and

as recrudescence of the disease undoubtedly does occur, it would be difficult to prove that these are not instances of recrudescence.

But in recognising all these cases as rickets some criterion must be fixed upon as characteristic of the disease. That used consists in the changes in the epiphyseal regions of the long bones, as demonstrated by external enlargement, by the occurrence of bone deformities, and by the skiagraphic appearances. These changes, however, occur in other conditions. In the first place they occur in such adolescent deformities as knock-knee and coxa vara, and in these they are local manifestations occurring at one epiphyseal line only, and not as part of a generalised disease. Such cases are usually excluded from the category of late rickets. In the second place exactly similar changes occur in the bones in certain forms of infantilism, the most important of these being that form associated with deficiency in the kidneys. The diagnosis of this condition from rickets is most important, for operation upon such cases has resulted in death from uræmia. In infantilism due to renal disease or to other causes the prognosis is as a rule bad, the children seldom living to adult life.

To conclude, rickety changes in the bones do sometimes continue throughout the period of growth; in some cases this can be ascribed to some definite known nutritional disorder, such as deficiency of the kidneys, and in such cases a fatal termination is the rule; in other cases no cause can be found, and the children eventually recover. These cases of continued rickets are much more resistant to treatment than are the ordinary infantile cases. Doubtless in the course of time such cases will be sorted into groups according to the cause of the nutritional disorder, and such sorting may eventually assist in determining the actual cause of rickets itself.

The rarer diseases which give rise to general distortion of bones are very differently described and named. In the following account an attempt is made to describe them very briefly under certain definite clinical types.

**Osteogenesis imperfecta.**—A rare form of primary general defect of the skeleton, in which the bones are incompletely formed and ossified before birth. There are often multiple fractures present at birth, and the long bones are distorted. Further fractures and distortions occur after birth, and the children seldom survive for long. The bones may be so soft that they can be bent with the hand. The long bones are most affected.

**Rachitic osteomalacia.**—A similar condition to osteogenesis imperfecta, but arising after birth, during the first six months of life. Multiple fractures and severe deformities arise. The bones unite, but bend both at the site of the fractures and throughout their shafts. The condition arises earlier than rickets, is not due to improper feeding, and leads to much more severe deformities. Boys and girls are both affected, and the children seldom survive for many years.

**Osteomalacia.**—Osteomalacia proper is characterised by a particular pathological process, namely, a softening of the bones by absorption of their mineral salts, the organic framework remaining in an imperfectly-ossified state and bending under pressure. Clinically it is a disease practically confined to women and occurring in them either at puberty or during pregnancy. The femora, pelvis, and lower part of the spine are most affected. The contrast between the greatly-distorted spine and femora and the fully-developed and straight tibiæ and arms is remarkable, and differentiates the disease from those previously described. The disease has apparently some connexion with the function of the ovaries; it has been seen to undergo a spontaneous cure at the menopause, and has been cured by removal of the ovaries. It is very rare, and its chief interest is to the obstetrician.

**Fragilitas ossium.**—A condition in which the bones are more brittle than normal and, without any tendency to bend, break as the result of slight violence. This disease may attack many members of one family and be traced through several generations. The tendency to fractures commences in childhood, and as many as thirty or more fractures may be recorded in one individual. The fractures unite, if well treated, without deformity. Such deformities as arise are due to malunion of fractures or to bending of callus. Nothing is known of the pathology.

### Deformities resulting from Paralysis.

The motor nerves in their course from the Rolandic area of the cerebral cortex to the muscles consist of two sections or relays. The upper extends from the cortex, where the neurone arises from one of the pyramidal cells, through the direct or crossed pyramidal tract, to that part of the cord whence the motor nerve arises, there to end in arborisations around the cells of the anterior horn. The lower or second relay consists of a neurone which arises from one of these cells in the anterior horn of the cord, passes out in the anterior root of the spinal nerve, and extends down to the muscle to terminate in an end-plate. These two neurones, the upper and lower motor neurones, have very different functions, so that paralysis due to a lesion of the upper motor neurone differs essentially from paralysis due to a lesion of the lower motor neurone. Stated briefly, the function of the upper neurone is that of initiating voluntary movement, of co-ordination and control: the lower neurone can by itself carry out certain involuntary or reflex movements; it is the conductor of impulses started in the upper neurone, and upon its continuity depends all muscular movement, whether voluntary or reflex; it also influences the nutrition of the muscle, and a complete lesion of the lower neurone is followed by rapid wasting.

A lesion of the upper motor neurone may be due to damage to the pyramidal cells in the cortex by pressure, hæmorrhage, etc., or it may result from injury to any part of the pyramidal tract. Its effects are shown in four chief ways. In the first place the affected muscles are usually found in a condition of spasm, the result of the removal of inhibitory impulses from the higher centres. Certain of the more powerful muscles in the affected limb in this way overcome the weaker ones, so that spastic deformities, usually of certain characteristic types, result; these deformities, at least in the early stages, are entirely due to muscular spasm, and can be corrected in the course of a few minutes by steady pressure. This spasm, although it results from the absence of central inhibitory impulses, depends upon the intact condition of the reflex arc; if the sensory side of the arc is abolished the spasm will disappear. For example, in paralysis of the lower limb of spastic type it is the rule to find fixed adduction of the hip; but section of posterior roots of the second, third, and fourth lumbar nerves, by abolishing the reflex arc, will cause the disappearance of the spasm and of the deformity. The second result of a lesion of the upper motor neurone is loss of control over the affected muscles; the lesion is often incomplete, a considerable voluntary power remaining, but this power is not under proper control; co-ordination is very imperfect, so that although movements of the affected part can be carried out, these movements are clumsy and do not fulfil their purpose. In many cases co-ordination can be greatly improved by re-education, provided always that the spasm is not too great. The third effect consists in involuntary and uncontrollable movements (*athetosis*). This, fortunately, is not a regular result. It is possibly due to cortical irritation;

but there is a certain amount of evidence that athetosis is due to an affection of the basal nuclei, with which some of the pyramidal fibres are connected. It is not capable of alleviation. In the fourth place certain affections of the pyramidal region of the cortex give rise to attacks of epilepsy, which may be Jacksonian in type. These attacks are undoubtedly due to cortical irritation, and are capable of alleviation only to a very limited extent. Affections of the upper motor neurone are not as a rule evidenced by trophic disturbances or by much wasting of the affected muscles, but this is not invariably so; occasionally in a spastic hemiplegia which has been present at birth the affected limb is found to be wasted and smaller in every way than its fellow.

The lower motor neurone may be paralysed as the result of injury to the anterior horn cell, most often by an attack of poliomyelitis, or of injury or disease of the nerve itself. It is characterised by loss of power in the muscle—flaccid paralysis with rapid wasting. Each muscle, however, derives its nerve supply from a large number of cells of the anterior horn, through a large number of nerve fibres, so that unless all these cells or fibres are affected the paralysis will be partial, the muscle being weakened but not completely lost. There is a considerable natural power of recuperation both in the nerve cells and in the axons. Many nerve cells, apparently completely paralysed as the result of poliomyelitis, subsequently recover, and severed nerves will as a rule have their continuity restored by growth of axons from their proximal ends, provided that the severed ends are accurately in apposition. Deformities result from paralysis of the lower motor neurone as the result of unbalanced action of those muscles which are not paralysed or are only partially paralysed, and which are relieved from the pull of their paralysed opponents. Such muscles pass rapidly into a state of permanent shortening, causing a deformity which cannot be corrected by pressure, and which in fact can in many cases only be corrected after section of the tendon of the contracted muscle. Such contraction in addition to producing a fixed deformity also keeps the paralysed opposing muscles in a constantly overstretched condition. Such an overstretched muscle has no chance of carrying out its normal work, and even if its nerve supply has recovered the muscle is kept out of action and has no chance of becoming strong; so that a fixed deformity helps to prevent the recovery of paralysed muscles.

One other result of lesions of the lower motor neurone requires mention. The part paralysed frequently shows trophic and vaso-motor changes, being constantly cold and often the site of chilblains and of trophic ulcers. These trophic changes may be due to the absence of muscular movement, but more probably they result from injury to vaso-motor and trophic nerves which accompany the motor fibres. They can to a large extent be alleviated by artificial warmth and by stimulation of the muscles.

Other tracts and connexions in the central nervous system in addition to the main motor tract are of importance in the production of deformities. As already mentioned, the continuity of the sensory tract, at least from the periphery to the cord, is necessary to the production of spasticity, although it is not at present known which form of sensation is concerned. Affections of the cerebellum may be accompanied by muscular relaxation, so that the affected muscles are hypotonic and the passive joint movements excessive. Cerebellar lesions are also accompanied by inco-ordination, which is capable of considerable improvement by re-education.

It will thus be seen that the deformities in the wider sense which are produced by nerve lesions are very complicated and require considerable analysis before they can be treated. Almost any disease of the central nervous

system may produce a deformity, but two special diseases or groups of diseases are of such importance in the surgery of deformities that they require detailed consideration. These are *acute anterior poliomyelitis* and the various *spastic paralyses* of children. Other local nerve lesions will be found described under *Regional Deformities*, and allusion to progressive muscular atrophy of the peroneal type and to Friedreich's ataxia will be found under *Pes Cavus*.

## Acute Anterior Poliomyelitis.

Acute anterior poliomyelitis, or infantile paralysis, is an acute infection, attacking chiefly young children, and, through its effect upon the cells of the anterior horn, producing a more or less extensive flaccid paralysis.

The disease occurs in epidemics and also sporadically. Small epidemics occur in this country, but most of the cases are sporadic. Children aged from six months to three years are most often affected, but the disease may occur at any age. Pathologically the lesion found is a small cell infiltration around the cells of the anterior horn in the spinal cord, often with small hæmorrhages. The nutrition of the anterior horn cells is immediately affected; these cells may recover or may be permanently injured and degenerate. The infecting agent is an ultramicroscopic organism, which passes through a filter. It has been recovered from the cord of fatal cases and from the throats of those suffering from the disease. Monkeys can be infected with the virus so obtained, and show the characteristic lesions in the cord. The organism has been cultivated by Noguchi. Nothing is known for certain about the mode of infection, but it is suggested that this is carried out, at least in some cases, through the bite of a stable fly. The disease is much more prevalent during the later summer months, when such flies are numerous.

*Symptoms and course.*—The onset of the disease is sudden, with fever and perhaps vomiting, convulsions and delirium. There may be great pain in the back and limbs. This acute stage is usually short; paralysis may be evident at the onset, or may be noticed only after the fever has passed off; the paralysis may increase in extent during the first three or four days. In many cases the acute symptoms are so slight as to escape notice. As soon as the acute stage is over a gradual recovery from the paralysis takes place. The degree of this recovery varies greatly; in some cases a very severe paralysis may recover almost completely, in others a much more limited paralysis may prove permanent. Spontaneous recovery may be expected to continue for a period of six months, even if no treatment is carried out. But for many years after this further recovery may be induced by proper treatment, particularly in cases where deformities have been allowed to arise, or where the partially paralysed muscles have never been put into use.

Very early after the attack the affected muscles begin to waste rapidly and trophic changes are found in the limb, which becomes cold and blue. Contractures arise during the stage of recovery; as already stated, they are due to the shortening of those muscles which have escaped, or of those which are only partially paralysed, or of those which recover most rapidly. These deformities usually arise at a period of from two to six months after the attack; they may arise as early as six weeks from the onset, or they may be found for the first time many years later.

In a certain number of cases of extreme severity death takes place during the acute stage as a result of paralysis of vital centres. In other severe cases an almost universal paralysis may prove permanent; children so paralysed readily fall victims to intercurrent disease. As a rule the eventual paralysis

is much less than would be expected from the intitial distribution. Only in very exceptional cases—for example, when all four limbs are affected—is the child unable to walk even with crutches.

*Diagnosis and method of examination.*—In typical cases the diagnosis of poliomyelitis in the acute stage is simple, although temporarily, until the paralysis becomes evident, the condition may be mistaken for some other acute infection.

In the later stages also the diagnosis is usually clear, although the absence of a history of an acute attack may sometimes arouse doubt. It may be taken that when a flaccid paralysis of one limb or of part of a limb, or with a more extensive distribution, is found, and when this condition has arisen in childhood and is not progressive, the condition is usually due to an attack of poliomyelitis.

In examining a case of poliomyelitis at any stage as a preliminary to undertaking treatment two facts only require to be ascertained. In the first place it is necessary to find out which muscles are completely paralysed and which are weakened, and in the second place it is necessary to determine whether there are any fixed contractures. To determine the extent of the paralysis the patient must be directed to carry out movements in order, so that the presence or absence and the strength of muscular power in certain groups of muscles is ascertained. For example, if one lower limb is affected the patient is placed flat upon his back and first told to raise the limb from the couch—the flexors of the hip and the extensors of the knee are thus tested together; then, the limb being held in the air, he is directed to pull it down to the couch, using the gluteal muscles against a resistance. Adduction, abduction, and rotation at the hip-joint are then similarly tested. The knee is then tested for voluntary flexion and foot movements tried, the child being directed to attempt to follow the surgeon's finger with his toes. This method is the most useful for a child who is old enough to follow the directions given, but is useless for infants: in them, however, much information can be obtained by altering the position of the child, gently tickling the feet, and in other ways stimulating him to movement; the presence or absence of voluntary action of most of the muscles may thus be determined if a little ingenuity and patience are exercised. When doubt is felt electrical examination of the muscles must be resorted to, and the electrical changes may be found of use in estimating the amount of damage to the muscles in all cases of poliomyelitis.

A normal muscle can be stimulated electrically either directly or through the nerve which supplies it. When stimulated directly its contraction is best secured if the electrode is applied over a certain point known as the motor point. Contraction is readily brought about by means of an interrupted current, or at the make and break of a continuous current. When a continuous current is applied to a motor point and the current is gradually increased, it is found that a contraction is caused with the smallest current when the stimulating electrode is the kathode and when the circuit is closed; with a rather stronger current a contraction is caused by closing the circuit when the anode is used; with still stronger currents opening the circuit will produce a contraction. This sequence giving the normal reaction of a muscle is usually expressed by saying that K.C.C. > A.C.C. The contraction produced by the make or break of a continuous current is a single twitch; there is a quick contraction followed immediately by relaxation which is almost equally rapid. If by injury or disease a muscle, or at least a large proportion of the fibres of a muscle, are cut off from the centre in the anterior cornual cells, changes soon take place in the reaction of the muscle to electrical stimulation.

At the end of from four to seven days the reaction of the muscle to the Faradic current can no longer be obtained, the contraction to make or break of a continuous current becomes more difficult to elicit, and finally in some, but not in all, cases the sequence described above becomes altered, so that closure of the circuit, with the anode as the stimulating electrode, causes a contraction with a less current than is necessary if the kathode is used. This is briefly expressed by saying that A.C.C. > K.C.C. At the same time the character of the twitch produced by making or breaking a continuous current alters. The actual contraction of the muscle is nearly as rapid as is that of a normal muscle, but the subsequent relaxation is much more prolonged. The sum total of these changes is expressed by saying that the muscle now gives the reaction of degeneration. This reaction may last for a period of months or even years; it may then, if the muscle recovers, give way again to a normal reaction; or, finally, all reaction to electrical stimulation may disappear. The significance of electrical reactions in poliomyelitis may be thus expressed. If reaction to Faradic stimulation remains, a considerable portion of the muscle has escaped and a rapid recovery may be looked for. If the reaction of degeneration is found, a large proportion of the fibres of the muscle must be cut off from their centre in the cord; but recovery is not hopeless—it is, however, likely to be slow. During the recovery of a paralysed muscle as a rule the first indication is the return of a reaction of degeneration; voluntary power then becomes evident, and the normal electrical reaction may only return much later. Not infrequently, however, voluntary power returns some considerable time before any electrical reaction can be obtained.

*Treatment.*—During the intial stage the treatment must be largely symptomatic, although, as it is now known that the serum of patients who have suffered from poliomyelitis contains a protective substance which can stop the progress of the disease if injected into a patient in whom the disease is still progressing, there is hope that in the future in cases which are diagnosed early there may be some hope of staying the progress of the paralysis.

As soon as recovery from the initial constitutional symptoms has occurred treatment of the paralysis should be commenced. The principles upon which this initial treatment of the paralysis is based are as follows. It is the exception to find that muscles are completely paralysed; as a rule some fibres escape from the first, and many other fibres will probably recover later. It should therefore be presumed that all the muscles which are found paralysed will recover to some extent. Their recovery will be more rapid and more complete if they are kept from being overstretched. In the lower limb it is found that the extensor muscles on the front of the thigh and leg are more frequently left permanently weakened than are the flexors. This is only partly due to the initial distribution of the paralysis; it is at least in part due to the fact that in the ordinary sitting and recumbent positions these muscles are left in the overstretched position, and as the weakened muscles are unable to raise the limb they have no opportunity of carrying out even small contractions, and therefore are unable to improve their strength by action. The first step in treatment is therefore to protect the paralysed muscles by suitable splinting and to prevent their being kept overstretched; the second step is to put such muscles as are capable of doing work into the position to carry out their work at as early as possible a time; the third principle is to use such other means as are at our command to maintain the nutrition of the muscles and of the rest of the limb.

A case of poliomyelitis seen soon after the acute attack is therefore treated in the following way. The extent of the lesion is defined. A splint is then

prepared which will relieve the paralysed muscles from being overstretched. This may be made of various materials. If the patient is being kept recumbent, splints made out of plaster of Paris and muslin, moulded upon the patient, are the simplest because they can be adapted to any part and fitted in any position. When the patient is getting up, splints made of light sheet metal (steel or "duralumin") or of leather or celluloid are useful. Celluloid is an excellent material, because of its lightness and because it can be made to fit any part by moulding it upon a plaster cast. In extensive paralyses it is not possible to support every muscle, and certain stock positions must therefore be used. For the upper limb it is best to keep the shoulder at a right angle (to support the deltoid), the elbow flexed (to support the biceps and brachialis anticus), and the wrist slightly hyperextended. In the lower limb the hip is kept fully extended, the knee fully extended, and the foot at a right angle and slightly inverted. These positions must of course be varied in different cases. If the erector spinæ is paralysed a complete bed must be prepared in which the child lies flat, the spine being thus kept straight and fully extended. If the glutei are paralysed a similar bed must be used. These splints must be of such a size as to permit of a lining of warm material, as it is most important that the affected part should be protected from cold. As soon as possible in the case of paralysis of a lower limb the child must be induced to walk. In general, in the early stages walking can be carried out in the splint which is being used for protection. Where a full bed is being used, however, a shorter splint reaching from the groin to the ground must be substituted. Exercises for the affected muscles combined with massage are also required at this stage. In carrying these out, however, it is important that paralysed muscles should not be put upon the stretch and should not be called upon to do work which is beyond their powers. For example, if the quadriceps extensor cruris is paralysed the knee should not be fully flexed, and no attempt should at first be made to carry out voluntary extension of the knee, for the muscle will almost certainly be unable to raise the weight of the leg. It may, however, be exercised by making the patient resist whilst the operator flexes the knee slightly (eccentric exercise), or by making the patient extend the knee whilst he lies upon the side, so that the full weight of the leg does not fall upon the quadriceps.

FIG. 43.—Celluloid splint applied to the lower limb for a case of extensive infantile paralysis

Various other means may be used at this stage to attempt to improve the nutrition of the affected limb. These should be used as accessory measures,

and should never interfere with proper splinting or with attempts to restore as early as possible the normal use of the muscles. Massage has already been mentioned Electrical stimulation is useful; it is best carried out by direct stimulation of the muscles with an electrode. Electric baths are useful as stimulating the general nutrition; when they are given, however, there is a risk of the limb being allowed to fall into a bad position, and there is also a risk that as the stimulus falls equally upon paralysed and unparalysed muscles the latter will be unduly strengthened and the risk of contractures thus increased. Radiant light is used by some as another method of improving the nutrition. If care is taken to keep the limb warm, to keep up the nutrition and to bring it into use as soon as possible, trophic disturbances will probably be avoided, and in addition the lack of development of the limb, which in neglected cases may leave a paralysed lower limb as much as 2 or 3 inches shorter than its fellow, will be reduced to a minimum.

If a case has been correctly treated from the commencement deformities should not arise, and eventually a stage will be reached at which the residual paralysis appears to be permanent. It may be stated that this stage is not reached until at least two years have elapsed from the attack, and even at that time the remaining paralysis must not be considered to be permanent unless correct treatment by support has been carried out throughout. Before considering the treatment of residual paralysis, therefore, it will be better to refer briefly to the treatment of cases which have been neglected and in which as a result deformities have arisen.

The first step in the treatment of such a case is to correct all fixed deformities. The means available for this purpose are :—

1. By splinting, either by simple splints upon which the limb is bandaged, pressure being exerted by the bandage, or by splints in which force is exerted upon the joint through a steel spring or by elastic traction. Extension by weight and pulley is seldom of use in the correction of paralytic contractures.
2. By tenotomy, either subcutaneous or open, or by tendon lengthening.
3. By force exerted by the hand whilst the patient is under an anæsthetic.

To take a simple example of the importance of correcting fixed deformities, it is not unusual to find in a neglected case of paralysis of the lower limb the hip-joint flexed, the knee-joint flexed, and the foot in the position of equinus, the whole limb hanging apparently flail and useless. In such a position the use of the limb in walking is a mechanical impossibility, for when the lower limb supports the weight in the normal standing position the hip is held fully extended by the action of the gluteal muscles, the anterior part of the capsule of the hip-joint being rendered taut and the joint so locked; similarly the knee-joint is kept fully extended and can be locked in this position automatically even without any muscular action—the foot, however, in order to allow of this must be at a right angle to the leg. In this normal position the line of the centre of gravity of the body passes behind the centre of the hip-joint and in front of the centre of the knee-joint, stability being secured with the minimum of muscular action; in fact, the only muscles necessary for stability in this standing position are the glutei. But until full extension of the hip and knee and the right angle position of the foot have been rendered possible stability in this standing position is out of the question. Such a flexed limb as has been described can in almost every case be at once rendered useful by correcting the fixed deformities.

The second step in the treatment is to apply such a form of apparatus as will enable the limb to be used for its natural purpose and will also prevent the tendency to recontraction. The limb must then be treated in this appa-

ratus, use being encouraged and the constant overstretching of the paralysed muscles prevented and improvement looked for. Only after at least two years of such treatment are further measures for the residual paralysis indicated.

Operative measures are thus only indicated in old-standing cases of paralysis which have been already treated by means of supports for a long period. These measures have for their object the improvement in the function of the limb. In the lower limb they aim particularly at enabling the patient eventually to discard all apparatus and to walk with a simple or but slightly modified boot. In the upper limb they may attempt to improve the use of a good hand which is handicapped by a flail condition of the shoulder, fixation of the shoulder joint by operation enabling the forearm to resume its use.

The two chief procedures thus adopted are *tendon transplantation* and *arthrodesis*.

**Tendon transplantation** has its uses in cases of strictly-localised paralysis, where, for example, a single muscle is paralysed in an otherwise almost perfect limb. The transplantation of another muscle to replace it may then enable the limb to be used normally. A good example of tendon transplanta-

FIG. 44.—Infantile paralysis with flexion contractures at hips and knees.

tion is the transference of the tendon of the tibialis anticus to the cuboid in cases of paralysis of the peronei, in which there is a constant tendency to the recurrence of a varus deformity.

**Arthrodesis** is an operation the object of which is to fix a joint and induce bony ankylosis. Arthrodesis is an operation for extensive paralysis in which there is no sign of return of power after prolonged treatment. It is an operation which should not be performed before the age of ten years and the utility of which is limited to a few joints; as a rule it is applied only to the ankle and tarsal joints and to the shoulder. Attempts may be made in lieu of performing an arthrodesis to fix a joint by inserting around it artificial ligaments of silk fixed into the periosteum of the bones. Such ligaments, if they can be retained, become enclosed by firm fibrous tissue, which may succeed in producing fixation of the joint. This operation is, however, still upon its trial.

Examples of these operations for paralysis will be found in the sections upon the paralytic deformities of regions, where the principles of the use of supports for special deformities are also mentioned.

## Spastic Paralysis of Children.

Paralysis of the spastic type, due to a lesion of the upper motor neurone, is of frequent occurrence in children. It may affect one limb only (*mono-*

*plegia*); more commonly, however, the arm and leg of one side are affected (*hemiplegia*), or both lower limbs (*paraplegia*), or both upper and both lower limbs (*diplegia*).

The actual pathological change in the brain may be a primary developmental defect, or it may be the result of injury or hæmorrhage occurring at birth, or it may be the result of an inflammatory disease occurring after birth. The latter is the usual cause of hemiplegia, the actual disease being a polioencephalitis — an infection of the pyramidal area of the cortex with the same virus as that of poliomyelitis, the pyramidal cells being injured in exactly the same way as are the cells of the anterior cornua of the cord in the latter disease.

FIG. 45.—Spastic paraplegia.

The distribution of the paralysis depends upon the site of the lesion in the cortex. If it is confined to the vertex, the lower limbs will be chiefly affected; if it extends further down the Rolandic area and is symmetrical, a diplegia may result; if it extends further down still, facial paralysis on one or both sides may be added; if it is unilateral, a hemiplegia of the opposite side results. Hemiplegia, as already stated, is most often acquired, resulting from an attack of polioencephalitis occurring in the first years of life; paraplegia and diplegia are more often congenital, due either to primary defect of development or to hæmorrhage at birth. These conditions are, however, frequently only noticed when the child is several months old. Occasionally spastic paraplegia occurs in several members of one family, and it may occur as a complication of congenital or acquired hydrocephalus. A progressive form of spastic diplegia occurs in congenital syphilis. This can be diagnosed by means of the Wassermann reaction. It is important to differentiate the syphilitic disease from a congenital diplegia, as the former is not suitable for treatment by operative measures. Spastic paralysis may also result from injuries to the head in childhood.

*Symptoms.*—In those cases of acquired paralysis which result from an attack of polioencephalitis there is an acute stage exactly resembling that of poliomyelitis, except that convulsions almost invariably occur. After this illness

the spastic paralysis, usually of hemiplegic distribution, is discovered. In congenital cases and in those which result from injury at birth the paralysis is often noticed only when the child is several months old. In the severe cases the spasticity is obvious; in the slighter cases advice may be sought because the child is late in sitting up or in walking.

The four phenomena found upon examination of the patient have been already mentioned—they are spasticity of certain muscles, inco-ordination, athetosis, and occasionally epilepsy. Any or all of these may be present. The spasticity in general gives rise to certain characteristic deformities. In the upper arm the elbow is held flexed, the forearm pronated, the wrist flexed and deviated to the ulnar side, and the fingers may be flexed into the palm or pointed out stiffly; the thumb is usually adducted into the palm. The lower limb is held adducted, flexed and internally rotated at the hip-joint, the knee flexed, and the foot held in the equino-varus position. In young children these deformities can be abolished by steady pressure exerted for a few minutes, but return as soon as this pressure is relaxed. In older children, however, there may be a certain amount of contraction of periarticular structures in addition to the muscular spasticity, and the deformity cannot then be completely corrected by this method. Although in a large proportion of cases the deformity is that described above, yet this is not invariable; different groups of muscles may be found contracted, so that, for example, instead of an equino-varus deformity a calcaneo-valgus may be found, and the same patient may present a different deformity at different times, the distribution of the spasm for some reason having altered. The spasm may be slight, inco-ordination being the chief symptom; the diagnosis must then depend upon a careful examination of the reflexes. The tendon reflexes in the affected limb are exaggerated, the superficial reflexes lost, and in the lower limb there may be ankle clonus, and certainly an extensor plantar response. Athetosis is comparatively infrequent—it most often occurs in the arm in cases of hemiplegia; it is rare in the lower limb and in paraplegic and diplegic cases. In typical cases of hemiplegia or paraplegia the gait is characteristic. In hemiplegia the child walks with the pelvis raised upon the affected side, the hip flexed and adducted, the knee flexed, the heel raised from the ground and the toe pointed in. In paraplegia and diplegia each lower limb is in this adducted, flexed, and inverted attitude; the feet are dragged along the ground without being properly lifted, and the knees cross.

The mental status of the patients varies greatly, but in the large proportion of cases of spastic paralysis it is in some way abnormal. The worst cases are imbecile; more often there is a slighter degree of mental defect. Most of the children, if properly trained, are able to assist in supporting themselves. Nearly all are highly emotional. The constant presence of muscular spasm probably affects the mental condition; it is thought that this spasm must be the cause, and the result, of a constant succession of nerve impulses reaching the brain, or at least the spinal cord, and that these exhaust the child and prevent his exercising properly his powers of observation, concentration and reason. It is at least certain that the abolition of spasm by surgical treatment may considerably improve the mental condition.

Epilepsy is infrequent in congenital cases and in those due to injury at birth; it is, however, common in cases of hemiplegia acquired after birth. It may arise at any age, but usually commences during childhood or adolescence; according to some authorities as many as 70 per cent. of children suffering from hemiplegia become epileptics.

*Treatment.*—The surgical treatment of spastic paralysis aims first at

relieving the muscular spasm and then at training the power of co-ordination of the muscles in the affected limbs. Diminution of the muscular spasm can be brought about in several ways—by operation upon the muscles and tendons, combined with the application of splints; or by operation upon the motor or upon the sensory nerves.

The simplest method is by operation upon the tendons. The tendon is divided or lengthened, or a portion about an inch in length may be exsected. The deformity is then completely over-corrected and the part fixed upon a splint. The muscles and tendons commonly treated by this method are the following:—

1. At the hip, the attachments of the adductor longus, adductor brevis, and gracilis are divided subcutaneously or by open operation in order to correct adduction deformity of the hip. The tensor fasciæ femoris and the anterior part of the gluteus medius may be divided by an incision over the great trochanter in order to abolish inversion deformity.

2. At the knee the hamstrings are divided by open operation.

3. At the foot the tendo Achillis is lengthened; it is necessary to lengthen this tendon and not simply divide it, as there is a risk of transforming an equinus deformity into a calcaneus.

After these operations the limb is kept fixed upon a suitable splint in the corrected position for a period of six weeks, and at the end of that time the second stage of treatment is commenced.

A second type of operation upon the tendons is more often used in the upper limb; it consists in transplanting a spastic muscle in such a way as to reverse its action. It may be instanced by the transference of the lower attachment of the pronator radii teres so as to convert it into an extensor of the carpus.

Operations upon the motor nerves aim at diminishing or abolishing the action of the spastic muscles by cutting off their nerve supply. Stöffel has worked out the intimate anatomy of the most important motor nerves and determined the position in them of the bundles which supply the muscles which are most often spastic; it is, however, advisable, in dividing partially or completely the nerve to any particular muscle, to test the nerve electrically during the operation and thus to make sure that the right portion is being divided. Instead of dividing the nerves and thus permanently paralysing the muscles, the nerve may be exposed and alcohol injected into it; a paralysis which will last for at least six weeks is thus produced, and during this time the opposing muscles may be able to regain their strength and so to prevent the full return of spastic contraction.

The third method of diminishing spasticity depends upon the fact that abolition of sensory impulses from a part will abolish spasticity in the muscles of that part. The operation of section of the posterior roots has been worked out by Förster, and is usually known by his name. It is performed chiefly for extreme cases of spasticity of the lower limbs which have resisted simpler methods. Through a laminectomy incision the posterior roots of the second, third and fifth lumbar and of the first and second sacral nerves are divided; these may be difficult to identify—in this case electric stimulation must again be employed. This and all nerve operations only remove the spasticity and have no effect upon secondary contractures; these require correction by manipulation and splinting.

In selecting cases for treatment those in which the mental defect is severe should be rejected. Others should not be subjected to surgical treatment until the age of seven, for the second stage of treatment, that of re-education,

requires the co-operation of the patient, and this is not possible in a very young child. In the first place treatment by tenotomy and splinting should be carried out in every case, unless the spasticity is very extreme. In these extreme cases and in those which are little improved by tendon operations Förster's operation appears to give the most hope. It is, however, a severe operation and associated with some risk to life, so that it should be postponed until the more simple treatment has been tried.

The second stage in the treatment consists in training muscular movements. It can be started early in cases in which the spasticity is slight, or in other cases after the preliminary surgical treatment. Massage is of little value; it must be gentle. Passive movements are necessary to ensure that the mobility of all joints is normal. Active movements carried out to their full extent constitute the chief item. The object to be attained, namely, increased control and re-education in co-ordination, must be borne in mind throughout.

## Deformities resulting from Disease and Injury to the Muscles.

Apart from the production of deformities in nervous diseases through the resulting paralysis or contracture of the muscles, deformities also arise in certain general muscular affections. The most important of these are the muscular dystrophies. For a complete account of these, works on nervous diseases must be consulted, but briefly the chief forms from which deformities result, and which are therefore likely to be met with in orthopædic surgery, are the following. The chief importance consists in the necessity for early diagnosis, as otherwise a totally wrong prognosis may be given, and treatment may be undertaken which will be of no avail and may even be detrimental.

1. **Pseudo-hypertrophic type.**—This is a disease of children and adolescents, affecting chiefly boys, and often all the boys in a family. A waddling gait with lordosis, due to weakness of the glutei, steppage gait, due to weakness of the extensors of the foot, and turning of the feet on to the outer side, due to weakness of the peronei, are the earlier symptoms. The enlargement of the muscles, especially of the calf, the weakness of the muscles of the pelvic girdle, the typical manner of rising from the floor by "climbing up the legs," and the family history will in most cases make the diagnosis clear.

The prognosis is grave; the disease steadily progresses, and in a few years the child becomes completely helpless, the upper limbs becoming affected. It is very exceptional for the patients to reach adult life.

2. **The facio-scapulo-humeral type** is more frequent in adults; in it the muscles of the shoulder girdle are affected first, then the face, and later the lower limbs and spine. It is more slowly progressive, and, owing to the distribution of the paralysis, deformities arise later, after the disease is easily diagnosable.

3. **The Charcot Marie Tooth or peroneal type,** in which the first symptom is the development of a pes cavus deformity. The lesion in this type is really nervous rather than muscular. It will be further alluded to under *Pes Cavus*.

A second type of muscular disease leading to deformity is that known as **myositis ossificans.** Generalised myositis ossificans is a rare disease arising in children or in young adults in which bony plates develop in or around the muscles, restricting their function and eventually immobilising the joints. The posterior scapular muscles are usually first affected; the disease is slowly

progressive, and exceptionally plates of bone may develop in the fascial sheaths of almost every muscle in the body, so that in an extreme case the entire body may be rigid and all the joints immobilised.

A much more common condition is that of localised *traumatic myositis ossificans*. This occurs most often around the elbow, less often in the deep part of the quadriceps extensor of the thigh and in the calf. It may follow a fracture or a dislocation, or a simple injury unaccompanied by either of these. In the elbow the history is that following an injury there is in the

FIG. 46.—Traumatic myositis ossificans in the brachialis anticus and in the triceps with excessive callus around a fracture of the lower end of the humerus.

course of a month or two a progressive diminution in the mobility of the joint. A hard mass may be felt, most often in the brachialis anticus, occasionally in the triceps. A skiagraph shows plates of bone in these situations which may be wholly separate from the humerus, radius, or ulna. The pathology is that there has been some tearing or stripping of the periosteum at the time of the injury and that from the osteoblasts thus liberated new bone develops. The development of these bony masses is increased, if it is not actually caused, by attempts to increase the mobility of the joint by force. Complete rest to the joint will in most cases cause the gradual disappearance

of the bone by absorption. In cases in which such disappearance does not occur it should be removed, any connexion it has with the humerus or ulna covered by a small flap of fascia, and the joint rested for several months to prevent the tendency to recurrence.

Contracture of a muscle after injury is an occasional cause of deformity, and must be watched for after penetrating wounds and deep cellulitis. In the early stages such contracture can be prevented or cured by careful manipulations and splinting. When apparently there is an actual fixed shortening of the muscle, *e.g.*, in talipes equinus after a penetrating wound of the calf, the patient should be examined under an anæsthetic after the wound has soundly healed, and the tendon of the muscle lengthened if necessary.

Ischæmic contraction of muscles will be found under Section IV.

### Deformities due to Scarring of the Skin.

Scars are of importance in the production of deformities, especially when they occur over the joints, more particularly over the flexor aspects. Much may be done to prevent contraction by scarring by secondary suture, by skin grafting, and by massage, manipulations, and splinting during the process of healing. All these can be safely carried out as soon as a wound is granulating.

When a scar has caused contraction, if any disability or deformity has resulted, an attempt should be made to undo this if possible. In addition to the use of massage, manipulation and splinting, the following methods may be used :—

1. Undercutting the neighbouring healthy skin and sliding it towards the scar, which must itself be freed from underlying structures. This is applicable to such areas as the axilla, where there is neighbouring loose skin.

2. Cutting a skin flap left attached by a pedicle and reflecting the flap on the area of the scar.

3. In such a part as the wrist a flap of skin may be raised from the abdominal wall, left attached by its ends, and the wrist, bared of scar tissue, inserted under it. When the flap has become adherent to the wrist it is detached from the abdominal wall (*pedicle graft*).

4. Division of the scar with subsequent skin grafting by Thiersch's method is not likely to be very successful, as the grafted area tends to contract greatly. Grafts consisting of the whole thickness of the skin may be used, however, for covering small areas, and have not the same tendency to contract.

5. Multiple punctures of the scar with a tenotome, the area being stretched greatly and fibrolysin rubbed into the incisions, have been recommended for scars which cannot be treated by plastic operations, such as many of those on the hands.

## Normal Contour and Movements of the Spine.

The normal contour of the spine is the resultant of the shapes of its individual vertebræ, of the mode in which these are fitted together, and of the habitual action of muscles upon them. Any disease or defect of the bones themselves, or any laxity of the ligaments, or any inequality in the action of the muscles may result in an alteration in the shape of the spine ; and such alteration is more likely to occur if these conditions arise during the period

of growth. Bone in general, as has already been pointed out, becomes altered in its shape and architecture as the result of the mechanical strains to which it is subjected. So that if the contour of the spine is altered the vertebral bodies will eventually be moulded to accommodate themselves to the new conditions. This applies even to cases in which the bones themselves are unaffected by disease, but it applies with more force to cases in which the bones are soft, as in rickets.

In the fœtus the spine as a whole presents a backward convexity extending throughout the dorsal, cervical, and lumbar regions; that part of this curve which is situated in the dorsal region, between the seventh cervical and ninth dorsal vertebræ, is fixed from the first, that is to say, it depends upon the shape of the bodies of the vertebræ and of the inter-vertebral discs. It persists throughout life and cannot be made to disappear, at least without the application of considerable force. In the cervical and lumbar regions, however, as soon as the erect attitude is assumed the backward convexity is replaced by a backward concavity. These concavities are maintained by muscular action and can be obliterated or reversed with ease. They tend to increase with growth until the full weight has been attained. Viewed from behind, the normal spine may be considered to form a straight line, although a slight deviation of the spinous processes to the right in the mid-dorsal region is so frequent as to be described by some anatomists as normal. It is not always quite safe to judge of the contour of the spine from the line of the spinous processes. As will be seen presently, a considerable rotatory deformity of the spine may be present although the spinous processes are not deviated; further, it is not unusual to find considerable irregularity in these processes, so that one or more of them project unduly or are tilted to one side without there being any deformity of the rest of the spine.

The movements of the spine are very complex. Taking the spinal column as a whole, they may be described as flexion, extension, lateral flexion, and rotation or torsion. Flexion and extension take place chiefly in the lower dorsal and lumbar regions and in the cervical region; the flexion allowed is less than would at first sight appear, much of the movement in stooping taking place at the hip-joints. Lateral flexion takes place throughout the spine; it is accompanied always by a slight rotation of the bodies of the vertebræ upon each other. Thus in stooping to the right the spine forms a long convexity to the left, but the curves thus outlined by the spinous processes and by the bodies of the vertebræ are not the same; that outlined by the bodies of the vertebræ is a part of a smaller circle, so that the vertebral bodies at the middle of the curve are displaced slightly to the left by a torsion of the spine. The amount of lateral flexion allowed by sheer elasticity and compressibility of the intervertebral discs before this rotation commences is very small. Allowing rotation, a fair amount of lateral flexion is permitted in the erect position, so that as a rule a young subject can thus reach down to the knee. But if the spine be flexed forward the amount of lateral flexion permitted is considerably increased, because lateral flexion is only possible with accompanying rotation, and rotation is much more free in the flexed position. This point is of considerable importance in the mechanics of the production of scoliosis. Torsion or rotation of the spine is fairly free in the cervical region, but in the dorsal and lumbar regions only occurs in association with lateral movement. If the pelvis be fixed and the body twisted so as to face to the right, a curve will be produced in the dorsal region which is convex to the left, accompanied by rotation of the bodies of the vertebræ at the middle of the curve towards the left.

## Congenital Abnormalities of the Spine.

Congenital abnormalities of the spine are not extremely rare. The vertebræ are developed each in three portions—the body and the two neural arches:

FIG. 47.—Congenital scoliosis. The second lumbar vertebra is double on the left side, single on the right side.

it is, however, not uncommon to find two ossific centres in the body, and probably this represents an original bilateral origin for this part. Defects of a vertebra may thus arise by defect or abnormality of any one of the four parts, or by failure of the parts to fuse properly. Perhaps the simplest type of abnormality is the conversion of a vertebra into one of a different series; the fifth lumbar vertebra may be united to the sacrum, or the first lumbar or seventh cervical may bear a rib. But such a change may not be symmetrical; one side of the fifth lumbar may be "sacralised," the other remaining normal; or one half of a vertebra may be suppressed or diminutive, either the body only or the neural arch being affected; or an extra half-vertebra may be interposed. These form one group of wedge-shaped vertebræ; a second group is formed by the occurrence of vertebral bodies which are single on one side, double on the other—that is to say, an extra half-vertebral body is interposed, but is fused with the adjacent body. To such fused vertebræ two ribs may be attached on one side, or a single rib may bifurcate at a little distance from the vertebra. Another class of abnormality consists in the failure of the two neural arches to fuse; this forms part of the deformity of spina bifida, but may occur without any external swelling (spina bifida occulta), and is not uncommon in conjunction with other congenital defects of the spine. Excluding spina bifida, these congenital defects of the spine are of importance chiefly on account of their secondary effects. An asymmetry of a portion of the spine necessitates a readjustment of the parts above in order that the erect attitude may be attained, a compensatory lateral curve thus arising. Such asymmetry of a portion of the spine is the usual cause of congenital scoliosis. Particular instances of congenital defects of the spine are considered under *Cervical Rib* and *Congenital Elevation of the Scapula.*

## Static Deformities of the Spine.

It is convenient to group together as static deformities lateral curvature of the spine and those alterations in the antero-posterior curvature in which the chief cause is mechanical rather than pathological. For although the static factor is only one of the factors in their production, yet in them the mechanics of the production of deformity and of its correction are more important than in any other section of surgery.

**Kyphosis.**—By kyphosis is meant an undue increase in the degree or in the extent of the normal backward concavity of the spine in the dorsal region. Kyphosis occurs in inflammatory diseases of the spine, such as spinal caries or spondylitis due to other infection, also as the result of muscular weakness or paralysis in tabes, Friedreich's ataxia, progressive muscular atrophy, and other nervous diseases. But, apart altogether from such pathological conditions, it is of very frequent occurrence as a deformity which is at first simply habitual and postural, but which if neglected becomes fixed. Such deformity is popularly known as *round shoulders.*

Whilst such a condition is extremely common amongst growing children and is due in the main to habit, certain accessory causes must be recognised and corrected in individual cases. The most important of these are sitting at too low a desk, so that the child finds it necessary to stoop, defective vision, and clothing which is too tight across the chest.

In kyphosis the dorsal convexity may be increased in length or in degree; in addition the head is poked forwards, the trunk as a whole tilted backwards, the scapulæ carried forwards and placed more obliquely than usual, and the chest is flat and its expansion poor. In young children there is often a

complete inability to attain a correct upright attitude, owing, apparently, to imperfect control over the muscles; so that although we must ascribe the deformity partly to muscular weakness, partly to lack of effort, an important element is the lack of education in muscular control.

In older children the kyphotic attitude becomes fixed and a secondary concavity in the lumbar region becomes habitual (*kypholordosis*), the shoulders remain stiff, and the chest expansion poor. Such a fixed deformity, besides being unsightly, may influence the general health by its effect upon the lungs.

*Treatment.*—The first point in the treatment of kyphosis is the removal of any accessory cause. When any visual defect has been corrected, a good sitting posture at the desk secured, and the suitability of the clothing ascertained, the further treatment is in most cases purely gymnastic. The clothing must not be tight across the chest, and as much as possible of its weight should be taken upon the hips, as little as possible upon the shoulders. Any general cause of ill-health which might serve to keep up muscular weakness must be remedied.

FIG. 48.—Kypholordosis.

Gymnastic treatment for kyphosis has three aims:—(1) To stretch the spine and the shoulders, so that there is no resistance to full extension of the spine and to full movements of the scapulæ and at the shoulder-joint; these stretching movements include a considerable forcible expansion of the chest. (2) To strengthen the erector spinæ and other spinal muscles, by means of active extension movements. (3) To improve the control of those muscles which maintain an erect attitude. The child must first be shown how to hold herself erect by muscular effort, then must be given more and more complicated exercises whilst she keeps this attitude, so that ultimately she maintains it without effort or thought. In young children there is as a rule little if any contraction, and the training in posture is the most important part of the treatment; in older children with a more fixed deformity preliminary stretching is essential.

Very occasionally other forms of treatment are required in kyphosis. If the patient is not sufficiently robust to undergo gymnastic treatment a support may be required. This must take its hold from the pelvis and act through shoulder straps which draw the shoulders back to a posterior support. Simple straps without any posterior support are useless. Very occasionally it may be necessary as a preliminary measure to correct a fixed kyphosis forcibly, and to fix the patient for a time in plaster of Paris in an improved position.

**Lordosis.**—By lordosis is meant an increase in the normal backward

concavity in the lumbar region. The lumbar region is that part of the spine by movement in which the balance of the trunk is adjusted. The lumbar concavity therefore varies greatly; it is in general more marked in stout people, and is increased if the abdomen increases in size as a result of deposit of fat and in pregnancy. As a rule lordosis is a secondary deformity due to such a readjustment of balance. It may be secondary to kyphosis, either a postural kyphosis or a kyphosis due to spinal caries, or it may be secondary to deformity of the hip. It is a prominent symptom in congenital dislocation of the hip, in coxa vara of the infantile type, and in fixed flexion of the hip after tuberculous disease.

The *treatment* of lordosis is the treatment of the primary condition to which it is due. In treating kyphosis and scoliosis by gymnastic methods there is a risk of producing lordosis; this must be met by adjusting the exercises, introducing some in which the lumbar curve is abolished by muscular effort.

**Spondylolisthesis.**—Spondylolisthesis is that condition in which the last lumbar vertebra is displaced forwards upon the sacrum. It is a rare deformity, due in the majority of cases to caries of the fifth lumbar vertebra, but occasionally to a fracture, and occasionally, apparently, to a congenital defect. There is a sharp lumbar concavity, with great prominence of the sacrum and buttocks. In women the promontory formed by the fifth lumbar vertebra may be felt in the pelvic brim by vaginal examination. In cases due to caries or to accident the pelvis and lumbar spine must be kept fixed until consolidation has taken place. Nothing can be done to correct the deformity.

**Lateral curvature of the spine: scoliosis.**—By lateral curvature of the spine is meant a habitual or fixed deviation of the spinal column or of part of it to one side of the middle line. Two conditions must be clearly distinguished from each other:—

1. A postural lateral curvature is one which can be assumed by the normal spine.

2. A structural lateral curvature is one which cannot be imitated in a normal spine, there being already a change in the anatomical structure of the vertebræ.

Although the former of these may progress into the latter, it does so in only a small proportion of cases; the vast majority of children with postural curvatures are cured or keep their postural curve; only very few develop a structural curve.

**Postural lateral curvature.**—Postural lateral curvature is extremely common amongst growing children. Investigations in schools have shown that from 16 to 25 per cent. of school-children habitually hold themselves in an asymmetrical posture. The postures most frequently assumed are naturally those which are apt to occur commonly in the child's daily life, and of these the following are the most important:—

1. By dropping one side of the pelvis, *e.g.*, by flexing one knee, a long convexity is produced in the spine towards the side upon which the pelvis is allowed to drop. The same effect is produced if a child has one leg shorter than the other. The curve thus produced reaches from the last lumbar vertebra to the cervico-dorsal junction, and is known as a total curve.

2. If the body is twisted to one side a curve is produced in the dorsal region convex towards the side from which the body is twisted, *e.g.*, twisting to the left produces a curve convex to the right.

3. Carrying a weight in the right hand usually causes the body to be tilted away to the left so as to readjust the balance, a left total curve being thus produced. But instead of this the right shoulder may be raised and a short curve produced in the upper dorsal region convex to the right.

4. In writing with the right hand as a rule the body is tilted away to the left, a left total curve being again produced; but again, instead of this the right shoulder may be raised, a high right dorsal convexity arising.

Investigations in schools have shown that these postural curves are equally common in boys and in girls, and that in 70 per cent. of cases the curve is a left total curve. In the other cases the curve may be a left lumbar curve, a high right dorsal curve, or more rarely a right lumbar or right total curve. Double curves do not occur as purely postural deformities, except in the form of transitional curves presently to be described.

It is natural to ascribe these postural curves to the habitual attitudes assumed in the use of the right hand, and this is the generally-accepted explanation of them. In some cases a special occupation may account for a special curve; in general, however, the explanation given will suffice.

It has already been explained that pure lateral movement of the spine in the dorsal and lumbar regions is impossible, that it is always accompanied by a certain amount of rotation of the vertebræ. In a lateral curvature this is shown as a rotation of the bodies of the vertebræ towards the side of the convexity, most marked at the centre of the curve. This rotation is present even in these postural curves, so that the erector spinæ muscle is more prominent upon the side of the convexity. In a left total curve there is further a slight twisting of the whole trunk, so that the left shoulder is tilted a little forward. This twisting can be voluntarily overcome by the patient twisting towards the left, but in so doing a curve convex to the right is produced in the dorsal region, the lower (lumbar) part of the original curve remaining. A double curve, convex to the left in the lumbar region, to the right in the dorsal region, is thus produced. Such a double curve produced in a normal spine, but resembling in type the curve of a structural scoliosis, has been termed a *transitional curve*, inasmuch as it is intermediate between postural and structural curves, and assists in explaining the mechanism by which the latter may be produced.

**Structural lateral curvature.**—Structural curvature is very much less common than postural curvature. In England it occurs in less than 1 per cent. of children, and it is more common in girls than in boys in the proportion of 7 to 1. Structural curves vary more in type than do the simpler postural curves; they may be single long curves to the left or to the right, or they may be double curves, most commonly convex to the left in the lumbar region and to the right in the dorsal region, or they may be triple curves, *e.g.*, left lumbar, right dorsal, left cervical. In naming a curve the direction of the convexity in the several regions from below upwards is stated.

In examining and recording a case of scoliosis it is convenient to differentiate three elements in the deformity. If a vertical line be drawn up through the centre of the pelvis, roughly indicated by the natal cleft, it will as a rule be found that there is a displacement of the trunk to one side, so that the line of the centre of gravity is no longer the mid-line of the body; this element in the deformity may be termed the "*displacement*." If instead of this line one passing through the spinous processes of the first sacral and last cervical vertebræ be used, it will be found that in the several regions there is a deviation of the spinous processes to one side or other of this line; this element may be termed the "*deviation*." The third element is the "*rotation*," already alluded to, evidenced by a projection backwards of the erector spinæ muscle or of the ribs upon the side of the convexity. All three elements may be found in postural curves, and in these displacements may be considerable in degree,

but sharp deviations and rotation of considerable degree are only possible when there has been a structural alteration in the spine.

The mechanism of the production of rotation deformity requires further explanation. Rotation is most considerable in curves in the dorsal region, although it may be quite well marked in the lumbar region. Three theories of its causation have been put forward :—(1) That it is merely an excess of the rotation which normally occurs when the spine is flexed to one side. (2) That it is dependent upon the leverage action of the ribs. It has been shown that each rib as it is raised in inspiration exerts a slight leverage backwards against

FIG. 49.—Structural scoliosis. The vertical line *a* is drawn through the centre of the sacrum to illustrate the displacement of the trunk to the right. The line *b*, drawn from the seventh cervical spine to the first sacral, shows the deviation of the spinous processes to the right in the dorsal, to the left in the lumbar region.

the transverse process of its vertebra. In the normal spine this leverage is equal upon the two sides, but if the ribs upon one side are put temporarily or permanently out of action the leverage will be unilateral and rotation of the vertebræ will ensue. In fact, this does occur after empyemata and in fibroid thickening of the pleura. In these cases the restriction of the movements on one side of the chest may result in the development of a lateral curve convex towards the sound side, with great rotation of the vertebræ. (3) The third theory depends upon the fact that the main mass of the vertebral muscles is situated posteriorly, so that if the patient consciously or unconsciously attempts to correct a lateral curvature by muscular action the result will be to

pull the laminæ and spinous processes towards the middle line, but to leave the bodies of the vertebræ comparatively unaffected. Probably the production of rotation deformity is a complex process, and all three of these factors may be concerned.

With any considerable rotation of the vertebræ secondary deformities of the thorax appear; the ribs upon the side of the convexity project posteriorly and are flattened anteriorly; those upon the opposite side are flattened posteriorly and project anteriorly. Further, in many cases of scoliosis changes in the antero-posterior contour of the spine arise, so that there is a kyphosis or kypho-lordosis associated with the lateral deformity. The clinical picture of a case of structural scoliosis may thus be very complicated.

A classification of the varieties of lateral curvature of the spine according to their origin may now be undertaken; these are:—

1. *Congenital scoliosis*, in which the condition exists from birth and in which

Fig. 50.—Structural scoliosis. The same case in the fully flexed position, showing the fixed rotation of the spine to the left in the lumbar region, to the right in the dorsal region.

there is some congenital defect of one or more vertebræ causing asymmetry. These defects have been already described. The scoliosis which results from them is of two sorts. Wedge-shaped or asymmetrical vertebræ may cause a short lateral curve at that portion of the spine in which they occur: this is the variety of curve found in congenital elevation of the scapula; its effect upon the rest of the spine is usually slight. But a wedge-shaped vertebra in the lumbar region may throw out the whole balance of the part of the spine above it, and so produce secondary compensating curves which are of more importance than the original curve. Congenital curves are structural from the first.

2. *Rickety scoliosis.*—This may be taken as a type of deformity arising in those diseases in which the bones are known to be soft and to be moulded into abnormal shapes with undue ease. Rickety curvatures arise early in life before the child has walked, are the result of sitting postures, and, owing to the moulding of the bones, soon become structural curves. The commonest situations for the curves are to the left in the lumbar or dorso-lumbar region and to the right in the upper dorsal or dorso-cervical region.

3. *Scoliosis secondary to tilting of the pelvis.*—This has already been alluded to. The pelvis may be tilted by shortness of one lower limb—a total curve towards the short leg is then produced, or by adduction of one hip—the total curve is then away from the adducted hip. It is important to note that this variety of scoliosis is postural only. A short leg does not of itself give rise to a structural scoliosis.

4. *Secondary to torticollis.*—This will be mentioned in the description of torticollis. The curvatures secondary to torticollis are postural, but they cannot be corrected until the torticollis has been treated, and if of old standing they may be difficult to correct then.

5. *Secondary to fibrosis of the lung or of the pleura and after empyema.*—This variety has already been described. It is structural from the first, is convex towards the sound side, and accompanied by much rotation. A further characteristic by which this variety may sometimes be recognised before the lungs have been examined is that the prominence of the ribs anteriorly upon the side of the concavity is absent, so that the diseased side of the chest is flattened both in front and behind.

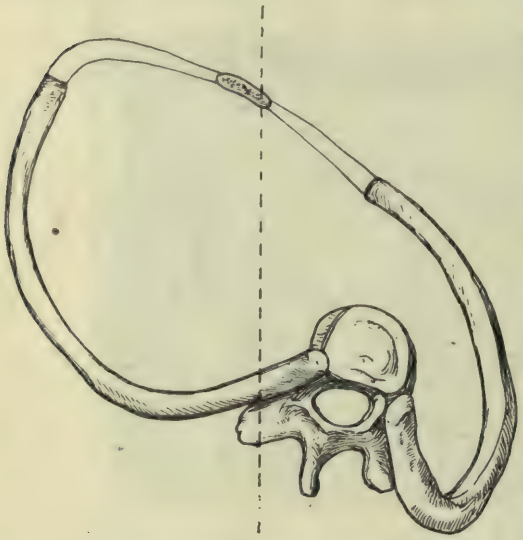


Fig. 51.—Diagrammatic section through thorax in severe scoliosis. The body of the vertebra is rotated to the right. The rib is prominent on the right side behind, on the left side in front.

6. *Scoliosis secondary to spinal caries.*—Spinal caries produces scoliosis in two ways. During the active stage of the disease there may be unequal spasm of the muscles upon the two sides of the spine, so that there is tilting to one side, a total curve being produced. This differs from a simple total curve in the presence of rigidity of the spine upon attempts at movement. The rigidity may be in one direction only—for example, it may only be noticed on attempting to side-flex the spine towards the side of the convexity. The second way in which spinal caries may give rise to scoliosis is by asymmetrical destruction of vertebræ. A secondary scoliosis may arise above such a point of asymmetry in exactly the same way as it does above a congenital defect of the spine.

7. *Paralytic scoliosis* is in the large proportion of cases due to poliomyelitis, although it may arise in almost any other disease of the nervous system. In poliomyelitis it follows partial or complete paralysis of one erector spinæ muscle, producing a long curve convex towards the paralysed side, which soon becomes a structural curve; or paralysis of one psoas may cause tilting of the lumbar spine towards the sound muscle, with a compensatory curve above; this curve also soon becomes structural. Paralysis may also produce scoliosis by causing fixed adduction or abduction of the hip-joint, or by causing shortness of one leg. The curves in this case are postural.

8. *Hysterical scoliosis* forms a distinct group. The deformity arises as a rule in adolescent girls or in young women; it is characterised by extreme lateral displacement of the trunk with a minimum degree of rotation; there is often an associated fixed adduction of the hip upon the side opposite to the convexity, the patient walking upon her toe.

9. *Adolescent or static scoliosis.*—This name is given to those cases of scoliosis arising during the period of growth and for which no cause other than habitual posture can be found. These constitute the large majority of cases of scoliosis; they include both postural and structural cases, and it is among them that the differentiation of these two classes of deformity is of special importance. In the following account of the investigation of cases of scoliosis, of their etiology, and of their treatment adolescent scoliosis is in the main referred to.

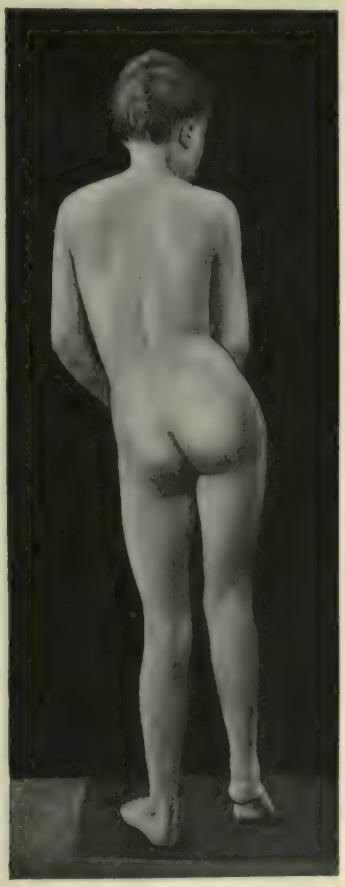


Fig. 52.—Hysterical scoliosis with fixed adduction of the hip.

**Symptoms of scoliosis.** — Ordinary scoliosis is not a painful affection. In the majority of cases the deformity itself is not noticed by the patient or by her parents, but the complaint is of an asymmetry of the hips or shoulders, often first noticed by the dressmaker. If a slight case of scoliosis is accompanied by pain the presence of some primary disease such as spinal caries should be suspected. A form of left lumbar curve occasionally arises in adults in association with neuritis of the lumbar or sacral nerves (*sciatic scoliosis*). In this there is a tilt of the lumbar spine towards the painful side, probably produced by contraction of the psoas, in which some of the affected nerves lie. In late cases of scoliosis, however, with severe fixed deformity, there may be much pain in the back or in the side over the ribs, possibly the result of pressure upon the nerve roots at their exit through the intervertebral foramina.

As a rule, then, patients suffering from scoliosis are brought for advice on account of the deformity, and this may escape observation until it is well established. At the present day many cases of scoliosis are discovered for the first time in the course of school medical inspection. A child with severe fixed deformity may be brought with the history that the condition has been present for a few months only. This is not necessarily untrue; a fixed deformity with much rotation of the vertebræ has been seen to arise in the course of three months whilst the child was under observation in hospital.

**Examination of a case of scoliosis.**—The patient's back must be bared down to the level of the great trochanters; the arms must hang free and not be engaged in holding the clothes; the shoes should be removed. A few minutes

should elapse before observations are made, in order that the patient may assume her natural attitude. The line of the spinous processes of the vertebræ is then noted, the contour of the side of the trunk, the relative height and position of the shoulders, and the prominence or otherwise of the ribs and erector spinæ on the two sides. If a lateral curve is noted, the next step is to

FIG. 53.—Postural scoliosis. Left total curve.

FIG. 54.—The same patient stretching her arms upwards and causing a disappearance of the curve.

determine whether the patient can correct this by her own effort; if she can do so the curve is postural. The two simple tests for this are—(1) to make the patient stretch upwards with her hands to the full extent; and (2) to place her with her hands grasped behind the head and the elbows and head pressed well back, directing her with the hand until the elbows are symmetrically placed and the spine as straight as possible. Next she is made to stoop forwards with

the knees straight until the fingers touch the floor. In this position all postural curves disappear, unless there is rigidity due to some disease. Slight structural curves may also disappear upon such full flexion, but as a rule in a structural curve some rotation deformity will remain and be evidenced by an undue prominence of the erector spinæ muscle or of the ribs upon the side of the convexity. Lateral flexibility of the spine is then tested; and finally, in the case of curves which have remained throughout the foregoing tests, the possibility of correction by force applied with the hand must be tried. The patient is then turned and examined from the front, general asymmetry of the body and asymmetry of the chest being noted, and the equality of the length of the legs ascertained by noting the height of the anterior superior iliac spines. Finally, in the case of a structural curve, the patient should be made to hang from a bar and the persistence of deformity noted. The various primary conditions to which scoliosis may be due are looked for, and if there is any possibility of spinal caries or congenital defect a skiagraph must be taken.

**Causation of scoliosis.**—The cause of postural scoliosis is a simple problem and may be dismissed in a few words. It is entirely the result of habitual posture. The development of full muscular control and co-ordination in children is slow; postures which they use constantly in everyday life become habitual, and only disappear in late childhood or adolescence when full control of the muscle is attained. This control is gained more readily in boys than in girls, on account of the greater attention paid to games and gymnastics by boys. But sooner or later most children gain this control and the postural deformity disappears. But with structural scoliosis the problem is different; out of many children who habitually hold themselves in an asymmetrical attitude, and in whom therefore the mechanical cause of scoliosis may be considered to be already in existence, only a very few develop a structural curve, and only one boy develops such a curve where seven girls become affected. It is necessary to assume that there is some additional cause in the case of these structural curves besides the habitual posture. If we consider the pathological anatomy of the condition, we see that in these curves there is early a deformity of the vertebræ themselves—the bodies of the vertebræ become wedge-shaped and the laminæ twisted. Such deformity indicates that the bone is perhaps unduly soft, and that, subjected to the strain thrown upon it by the habitual posture, it becomes moulded and so allows of the production of a deformity which is impossible in the normal spine. Upon this assumption adolescent scoliosis falls at once into the same group as do such other adolescent deformities as genu valgum and non-traumatic coxa vara; in these changes in the epiphyseal regions have been demonstrated similar in character to those which occur in rickets, and undoubtedly leading to the formation of bone which is softer than it should be. It seems rational to suppose that there is a similar defect in the ossification of the vertebræ in structural scoliosis, so that these are altered in shape as the results of strains which are insufficient to affect normal bone. The classification of scoliosis into postural and structural varieties thus becomes doubly important: in both the habitual posture is the mechanical cause of the deformity; in the structural cases, however, there is the added fact of the softness of the bones. Of the cause of this softness we are at present ignorant, but so long as it persists, so long must there be a risk of the deformity progressing rapidly.

**The treatment of scoliosis.**—Before treatment can be undertaken in a case of scoliosis a complete investigation must be carried out, the deformity classed as postural or structural, and any primary cause, such as congenital defect of a vertebra, torticollis, short leg, deformity of one hip-joint, paralysis, etc.,

determined. The first step in treatment is evidently to correct or alleviate these primary causes as far as this is possible—for example, torticollis may be corrected by operation; short leg may be compensated by a high boot. The questions then remaining are the treatment of a postural curve, the treatment of a structural curve, and the special treatment necessary in cases due to disease of the lung and paralysis and in hysterical scoliosis.

Postural scoliosis can be corrected by the properly-directed action of the patient's own muscles. Its cure, therefore, is entirely a question of training those muscles until this corrected posture becomes habitual—that is to say, the cure of postural scoliosis is a muscular problem, is a question of proper gymnastic treatment. In structural curves the problem is different: in these there is already a malformation of the spine, due to two factors—first, undue softness of the bone, and, secondly, the pressure of the weight of the body in certain attitudes. Here there is a three-fold problem—(1) to cure or arrest the disease which gives rise to the softness of the bones; (2) to correct or over-correct the deformity by mechanical means; and (3) to maintain the corrected position until the bone is firm and until there is no tendency to recurrence of the deformity. This ideal of treatment is at present impossible for several reasons—the exact nature of the disease which affects the bones is unknown, the mechanical difficulties of correcting the deformity are often insuperable, and the mechanical difficulties of maintaining a corrected position are also often very great. So that in some cases it is necessary to be satisfied with an imperfect result, with a partial correction of the deformity, or with some treatment which will hide the deformity. Gymnastic treatment in structural curves is useful in improving the general health of the body and in enabling the patient to maintain the best possible attitude; often this attitude is one in which the curve is almost or even completely hidden, and the patient, although not cured in the strict sense of the word, is improved as far as she or her parents consider necessary. So that although gymnastic treatment does not constitute a complete cure in structural scoliosis, it is often the only treatment necessary. It should never, however, be carried out as the sole treatment in progressive cases, or in cases with considerable deformity.

For purposes of discussion of treatment it is convenient to classify cases of structural scoliosis into three groups—(1) those in which the deformity (except possibly a slight degree of rotation) disappears upon suspension or is easily corrected by pressure with the hand; (2) those in which the deformity is more fixed but can be to a large extent corrected by considerable force applied through straps; and (3) those in which the deformity is practically unaffected by attempts to correct it.

**Treatment by physical exercises.**—It is only possible here to indicate the principles upon which physical exercise treatment is based; for details of the exercises special works must be consulted. Briefly stated, the principles involved are the following:—

1. The control of the muscles must be improved, so that a correct attitude is obtained, first as the result of direction, then by the patient's own unguided effort, and finally unconsciously and without effort. This principle is far the most important, and is often lost sight of by those engaged in remedial gymnastic work; for this reason it is here placed first.

2. The spinal muscles and the muscles in general must be strengthened. In particular those muscles which by their action correct the curve require to be rendered stronger; these muscles are, speaking generally, those upon the convex side of the curve.

3. When there is any mechanical difficulty in correcting a curve, this must

be overcome by stretching movements carried out by the hand of the manipulator, or by straps. This is generally stated as the principle of stretching the shortened structures upon the concave side of the curve.

Of these three principles the first is the important one in the treatment of postural curves; in carrying it out the exercises which are most useful are those classed as educational exercises in the Swedish system. In working upon the second and third principles exercises classed as remedial are required. It is advisable that the instructor who carries out these exercises should be trained in both remedial and educational work.

FIG. 55.—Plaster correction jacket applied by Abbott's method for correction of a right dorsal curve.

Klapp has introduced a system of exercises carried out in the creeping posture upon the floor; these are useful because they are simple, easily learnt, and easily carried out by children with very little supervision.

**Correction of structural scoliosis.**—Those cases of structural scoliosis which can be easily corrected with the hand are properly treated by gymnastic methods, with the addition of a support to maintain the spine in an over-corrected position between the periods of exercise treatment. Those cases which cannot be so corrected first require treatment by forcible means until they are rendered correctable. The simplest method of straightening out a scoliosis is by suspension of the body. This method was formerly a favourite one, and is still useful for certain cases, particularly for children of poor

physique, who are unable to stand more drastic treatment. The patient is suspended by a head sling until the heels are off the ground, the toes still touching; a plaster of Paris jacket is then applied from the pelvis to the axillæ and moulded well upon the pelvis and against the region of the convexity. If the curve is a high one the plaster may be carried up to the head. The best possible position is thus maintained in the plaster for a period of three months. A second suspension and a second plaster will then correct the deformity still further. When the plaster jacket is finally omitted, when no further correction is obtainable, it is necessary to apply a removable support, to be worn whilst exercise treatment is carried out to restore the strength of the muscles.

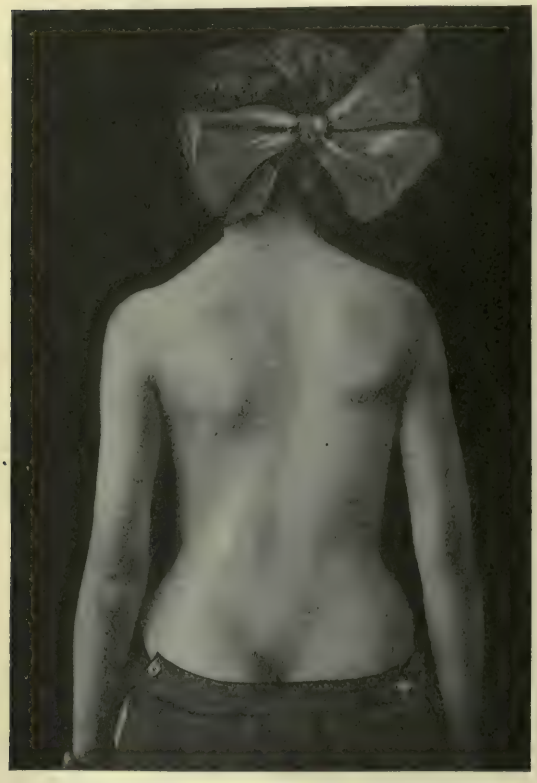


FIG. 56.—Slight structural scoliosis Right dorsal curve.

This suspension method has the defect that the correction is not very forcible and that over-correction is not possible. The methods which are more extensively used at the present time are those in which correction is carried out in the recumbent position by the lateral pull of straps. The details of the mechanical methods are too complicated for description here, and reference must be made to the works of Lovett and Abbott. The method of the latter surgeon is briefly as follows. The patient lies upon her back upon a canvas sling; the legs are raised so as to flex the hip-joints and so produce flexion of the spine, rotation of the vertebræ being more free in the flexed spine. Straps are then applied to correct the lateral displacement and deviation at the principal curve, with counter-straps under the axilla and around the pelvis to prevent the whole trunk being pulled to one side. A plaster jacket is then applied extending from the pelvis to the axilla. In this jacket a large window is cut posteriorly upon the side of the concavity of the curve; this window allows of expansion of the chest at this region, and also allows of the insertion of pads against the convexity still further to correct the curve. Other small windows are cut for the insertion of these pads. The jacket is worn until no further correction can be obtained, and for three weeks after. It is then removed, and if correction is incomplete is replaced by another; if correction is complete a removable support is made and exercise treatment commenced.

The degree of correction which can be obtained in any case depends upon the fixity of the curve and upon the physique of the patient. The application of a correction plaster is a severe form of treatment, and is not well stood by patients of poor physique. In those cases in which practically no correction can be obtained by a determined attempt to pull the spine straight with straps it is useless to try these methods of forcible correction.

Removable supports of many different sorts are used in the treatment of scoliosis. The first essential in such a support is that it should have a firm hold upon the pelvis. Because their hold is not firm most of the metal supports are useless. A support must further hold the spine in an improved position; if possible it should hold it in an over-corrected position. In order that it may do so the support may be fitted upon the patient whilst she is suspended — this will correct but not over-correct—or it may be fitted upon the patient whilst she is held in the over-corrected position by the hand, or it may be made upon a plaster cast taken in the corrected position. The latter method is the best; the only reason that it is not invariably used is that its application is laborious. The best support is an enclosing one lacing down the front or sides and made of poroplastic or celluloid. It should be made to fit close upon the convex side of the curve, loose upon the concave side, and should in most cases reach only as high as the axillæ. The chief objection to an enclosing support is that it restricts the respiratory movements. But by allowing some space inside the support upon the concave side movements are permitted upon that side, and the rest of the respiratory movements must be carried out with the upper part of the chest, the patient lifting herself up out of the support and so still further correcting the deformity.

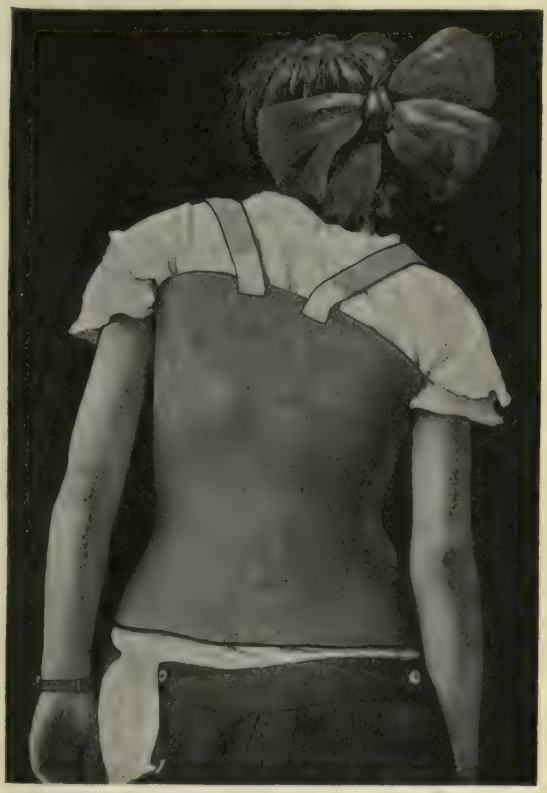


FIG. 57.—The same patient fitted with a support in which the curve is reversed.

In some cases of scoliosis it is advisable to rest the patient in a recumbent position, either continuously or for considerable periods daily. It is useless simply to give orders that the child is to lie on her back. It is improbable that she will lie for any considerable time without curling herself into a position in which the spine is curved, and even if she does there will be no considerable

pressure upon the prominent part of the curve. When recumbent treatment is desired a plaster of Paris bed should be made moulded to the patient's back, except that a hollow is left over the concavity. This bed should be padded so as to exert pressure upon the chief prominences, and the patient made to lie in it always at night, and for whatever part of the day is considered necessary. This method of treatment is specially indicated in cases which are rapidly progressive. It will necessarily be followed up either by the use of a removable support, or by gradually introducing exercises and diminishing the periods of recumbency.

Paralytic scoliosis requires the application of a support from the first, and this support will probably be required permanently. Scoliosis secondary to disease of the lung requires the application of a support, which should leave plenty of room upon the concave side, during the progressive stage. Breathing exercises in which one side of the chest is used are required. This form of scoliosis is usually permanent, but after a few months not progressive.

Hysterical scoliosis must be treated chiefly by persuasion. Ordinary exercise treatment is as a rule very unsuccessful; the patients do the exercises badly, and apparently delight in so doing them. If the case is seen early, examination under an anæsthetic will often result in a complete cure.

## Tuberculous Disease of the Spine: Spinal Caries.

Spinal caries (Pott's disease: Angular curvature of the spine) is an infection of the vertebræ with the tubercle bacillus. In the large majority of cases the disease commences in the vertebral bodies; very occasionally in the cervical region the laminæ are first affected. The disease is most common in the first five years of life, but it may occur at any age. Any part of the spine may be affected, but the dorso-lumbar junction is the portion most frequently attacked.

*Pathology.*—The pathological process is a tuberculous osteitis of one or more vertebral bodies; the initial lesion may be in any part of the body of a vertebra, but the anterior part is more frequently attacked than the posterior, and the regions near the epiphyseal plates are specially liable to be affected. The bone is softened and caseous patches arise; there is a certain amount of destruction of bone, but the formation of large sequestra is uncommon. If the disease is untreated the vertebral bodies are destroyed; the intervertebral discs offer some resistance to the extension of the disease from one vertebra to the next, but eventually they disintegrate and are also destroyed. The vertebræ fall together anteriorly, and a sharp angle backwards is thus produced in the spine. If softening and suppuration take place, an abscess forms in the neighbourhood of the vertebral bodies. This abscess is at first prevertebral or in the dorsal region mediastinal; if it extends it most often tracks laterally and extends along the fascial planes marked out by the divisions of the spinal nerves, pointing posteriorly (along the posterior primary divisions), or laterally (along the lateral branches), or anteriorly (along the anterior muscular branches, such as those of the lumbar plexus).

The abscess may, however, extend behind the bodies of the vertebræ into the vertebral canal, when it may press upon the spinal cord; or it may extend anteriorly as a retro-pharyngeal or mediastinal abscess, or in the lumbar region it may track along the iliac vessels. Rarely it may strip up the anterior common ligament of the vertebræ (*tuberculous periostitis* of the spine).

*Causation.*—The infection must take place through the blood-stream. An injury to the spine is a common immediate cause; this probably simply offers a site at which tubercle bacilli, already infecting the patient, can settle. The

origin of the infection is not at present settled. Many of the patients come of a tuberculous stock and are exposed to infection from a tuberculous parent. On the other hand, some pathologists believe that the infection is of the bovine type of tuberculosis and that the infection is derived from food, particularly from milk. The decision upon this point must await further investigations of the type of tuberculosis found in spinal caries, but at present evidence is

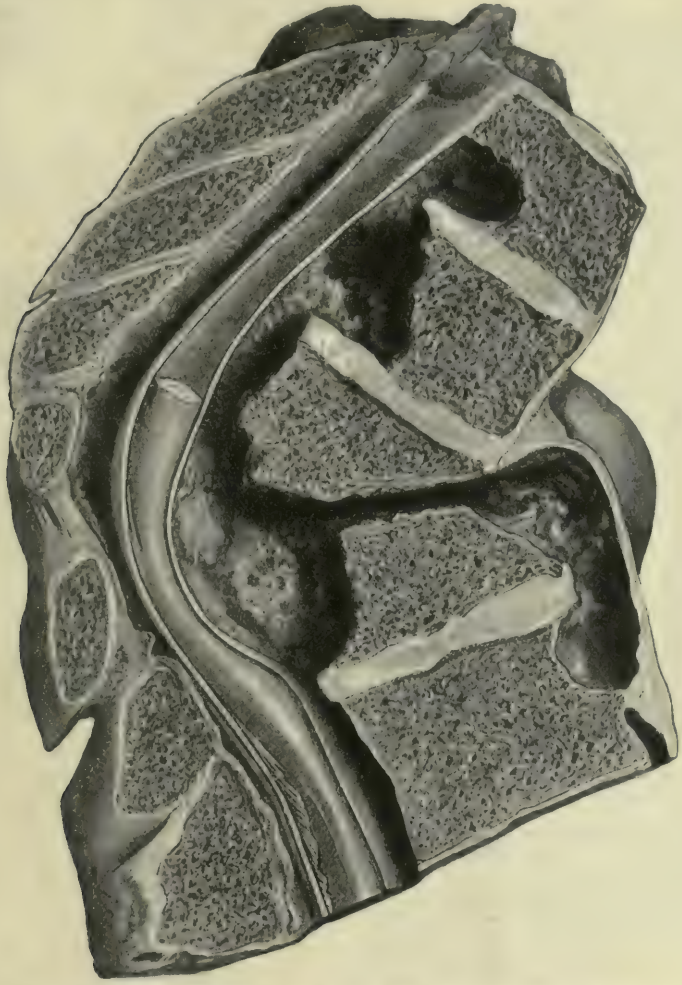


FIG. 58.—Spinal caries. The bodies of the vertebræ are partly destroyed, an abscess resulting. The abscess presses posteriorly upon the spinal cord and also extends in front of the bodies of the vertebræ. (St. Bartholomew's Hospital Museum.)

accumulating that the infection is human in type and that infection from human contacts is the more important source.

*Symptoms.*—The symptoms of spinal caries are pain, muscular rigidity, and, later, deformity. As many of the patients are so young as to be unable accurately to describe their symptoms, it is important to note that the initial indications that something is wrong often point only very indirectly to the spine as the seat of the mischief.

The pain may be felt in the back as a dull aching; but the more severe pain is usually felt along the nerves which leave the affected part of the spine, so that it may be described as headache, or as a pain in the stomach. It is increased by sudden unguarded movements, so that the child may move stiffly and carefully; when painful movements occur during sleep the child may cry out (*night cry*).

Muscular rigidity shows itself in certain characteristic attitudes and in an alteration in the habits and movements of the child. Hence the first indication of spinal caries is usually the refusal of the child to run, jump, or play naturally; he stoops stiffly with flexed knees and hips, supporting his weight upon his hand, or he stands habitually resting upon some piece of furniture. All such unnatural alterations in the habits of a child should lead to a careful examination of his spine, and spinal caries may then in the majority of cases be diagnosed before any deformity is present. Sometimes the first symptom discovered is the presence of a lump in the back (the angular curvature), but this usually means that the parents are unobservant.

*Physical signs.*—The deformity due to muscular spasm, the limitation of certain movements on account of muscular spasm, and the presence of actual deformity of the spine must be looked for. The name *angular curvature* is an unfortunate one, for spinal caries is capable of diagnosis before any bone deformity has arisen, and if then properly treated it may in many cases be cured without the development of an angular curve. If a definite posterior angle has already arisen the diagnosis is seldom in doubt.

Deformities due to muscular spasm and methods of testing for rigidity require separate description for the several regions of the spine. But certain general tests for spinal rigidity are useful. A healthy child should be able to flex the spine forward from the upright position until the fingers touch the floor, the knees remaining straight and the spine forming a uniform posterior curve. He should be able to flex the trunk laterally until the fingers of the downwardly-stretched hand reach below the knee, and this lateral flexion should be symmetrical on the two sides. If he be placed prone upon a couch and the feet lifted, the spine should assume a long backward concavity until the thighs make an angle of 75 degrees with the couch before the abdomen commences to rise. Finally in every doubtful case an exact diagnosis can be made by means of a skiagraph, for spinal caries is a disease of the vertebræ themselves, and even at quite an early stage definite alterations are evident in skiagraphs.

In **caries of the cervical region** the pain is referred to the occiput or to the ear, or perhaps to the shoulder or arm. The muscular spasm may produce wry-neck or an upward and forward tilting of the chin. Weakness and fear of movement often lead the child to support the head with the hand. Loss of movement is specially shown in rotation of the whole trunk rather than of the neck. Angular curvature is slight and late in arising. Abscess may develop at the back of the pharynx or in the posterior triangle of the neck. Disease of the occipito-atlantal and atlanto-axial articulations is indicated by loss of nodding movements and of rotation respectively.

The diagnosis of cervical caries has to be made from congenital torticollis, from inflamed cervical glands leading to muscular spasm, and from sprains and dislocations of this part of the spine.

In **caries of the cervico-dorsal spine** the pain is referred to the arms, clavicular region, or sternum. Muscular rigidity may cause wry-neck or the forward tilting of the chin already mentioned; in addition the shoulders are usually raised and square. Owing to the lack of mobility of this part of the spine rigidity is difficult to demonstrate. Angular curvature is an early and

marked feature. Abscess pointing externally is rare: when present it is usually confined to the mediastinum; it may, however, point in the posterior triangle of the neck, in the axilla, or dorsally at the side of the spine. An unnaturally prominent seventh cervical spinous process may be mistaken for caries in this region.

In **the upper dorsal region** the most marked angular deformities arise. This is due to two causes—(1) the natural backward convexity in this region assists the early production and rapid increase of the posterior angle; and (2) on account of the lack of mobility of this part of the spine the early symptoms of disease are vague and the diagnosis is often not made until late. The pain is referred to the chest and abdomen; it is often accompanied by a hard cough and grunting respiration. The attitude varies; there may be raising of the shoulders and shortening of the neck, with either a forward tilt of the whole body, or else a particularly erect carriage with compensating lordosis. Lateral deviation of the spine is not uncommon. Muscular spasm is demonstrated by the general tests; the test for lateral mobility is important, and spasm of the psoas may be present. An abscess may point posteriorly or remain in the mediastinum, or it may track downwards beneath the crura of the diaphragm and enter the psoas muscle. Paralysis is more common in disease of this region than in disease of other parts of the spine. Special difficulties in diagnosis are from scoliosis and postural kyphosis.

FIG. 59.—Spinal caries in the lumbar region with a lateral tilting of the spine. This case differed from a simple scoliosis in that the spine was very rigid.

**The lower dorsal and lumbar regions** of the spine are the most frequent sites of the disease. The severity of the deformity diminishes and the tendency to abscess formation increases as the lower part of the spine is approached. The pain is felt in the abdomen, in the inguinal region, or down the thighs and legs. As this is a mobile part of the spine muscular rigidity is very noticeable. It induces a very careful walk with a certain amount of waddle, the child often stepping upon the toes. Lordosis may occur in the early stage, only changing later to a posterior convexity. Lateral deviation of the spine is common and tests for lateral mobility of the spine important. In active disease of this region there will nearly always be found some spasm of one or

both psoas muscles. This may be evident upon inspection, the spastic muscle producing flexion of the hip, or a tilt of the lumbar spine to one side. But if not evident it may be readily tested for by placing the child prone upon a couch, holding the pelvis down with one hand, whilst an attempt is made to hyperextend each hip in succession. This should be possible to the extent of raising the thigh completely clear of the couch; if the psoas muscle is contracted this hyperextension is impossible, and attempts to carry it out may be painful.

In this region abscess formation is common, and the directions in which abscesses may track are numerous. The abscess may be found pointing over the erector spinæ as a dorsal abscess, or laterally, escaping through Petit's triangle, as a lumbar abscess; or it may extend anteriorly in the substance of the psoas muscle as a psoas abscess and point above Poupart's ligament external to the iliac vessels or below Poupart's ligament internal to the

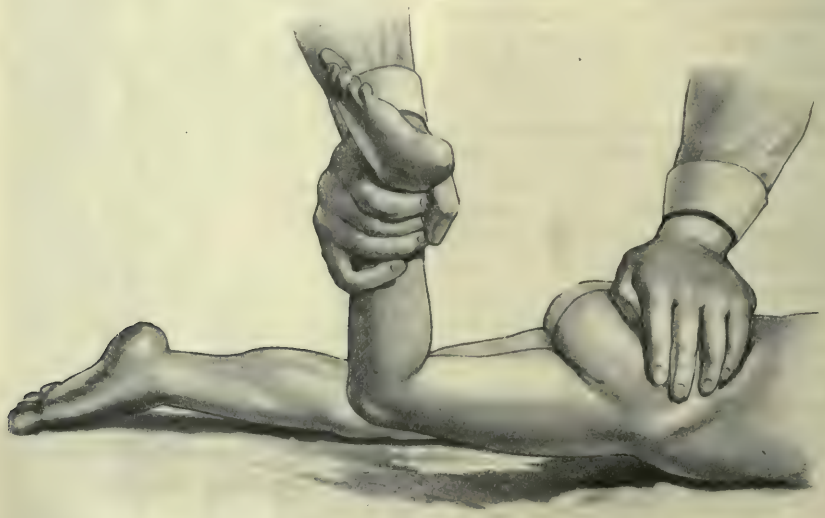


Fig. 60.—Method of testing for spasm of the psoas muscle.

femoral vessels, or, escaping from the psoas, it may track to almost any distance down the inner side of the thigh. If it arises anteriorly to the psoas or escapes from that muscle high up, the abscess may track laterally, pointing opposite the anterior superior iliac spine as an iliac abscess, or it may pass on into the thigh with the external cutaneous nerve. Passing internally along the internal iliac vessels it may reach the pelvis, and, escaping through the great sciatic notch, form a gluteal abscess, or it may extend into the ischio-rectal fossa or into the perineum. All these abscesses are situated partly in direct relation with the peritoneal cavity, and any of them may therefore yield an impulse on coughing. They may if incompletely examined be taken for herniæ.

Caries in this region may be mistaken for disease of the sacro-iliac joint or for hip disease. The diagnosis has also to be made from the other causes of deep-seated abscess.

*Fever* in the form of an evening rise of temperature is frequent in the early

stages of spinal caries, particularly if the onset of the disease is acute. As a rule this is temporary and subsides after a few weeks' treatment. A regular evening rise of temperature in a more chronic case should lead to the suspicion that some complication, an abscess or a dissemination of the tuberculous disease, is arising.

*Diagnosis.*—Most of the conditions liable to cause difficulty in diagnosis have been already indicated in dealing with the various regions. The diagnosis from them must depend upon the careful application of the tests for rigidity of the spine and upon the appearances found in a skiagraph. In adults new growth of the spine, erosion of the vertebræ by an aneurysm, and possibly syphilitic osteitis of the spine may closely simulate spinal caries. New growth of the spine is usually distinguished by the early and very severe pain felt along the nerves.

Other causes of spinal deformity—lateral curvature, kyphosis (rickety or static), exostosis of a spinous process, etc.—are usually unaccompanied by rigidity. Hysterical spine is, however, sometimes painful and rigid; it not infrequently occurs in association with some natural prominence of the lower dorsal spines. Movement of the spine must be tested with the

Fig. 61.—Spinal caries with severe deformity in the lumbar region and iliac abscess.

patient off her guard. The absence of psoas rigidity is always significant in suspected disease of this region.

*Skiagraphy.*—A certain diagnosis can always be made by means of a skiagraph. Antero-posterior and lateral views should each be examined. Actual destruction of part of the bodies of one or more vertebræ may be found, or if the lesion is an early one the destruction may not be recognisable as such; but it may have resulted in a too close approximation of two of the vertebræ, and this, particularly if there is any blurring of the outline of the upper or lower margin of one of the bodies, is very important. An abscess is frequently evident in the skiagraph even when it is not palpable; in fact, in a large proportion of cases of spinal caries abscesses are shown in the skiagraph. The abscess casts a shadow around the diseased area in the spine, with a sharp outline; the presence of such a shadow is a considerable aid to diagnosis. Apart from the assistance which is given by a skiagraph in diagnosis, it is also possible by this means to map out accurately the extent of the disease, which vertebræ are destroyed and to what extent. This may assist in prognosis and in treatment.

*Prognosis.*—Spinal caries is a serious disease. The direct mortality is difficult to ascertain on account of its chronic course. When death occurs it is the result of some complication, either of general tuberculosis or of septic

infection of an abscess, or of some superadded disease. The chance of a good recovery is much greater in children than in adults. If deformity has not

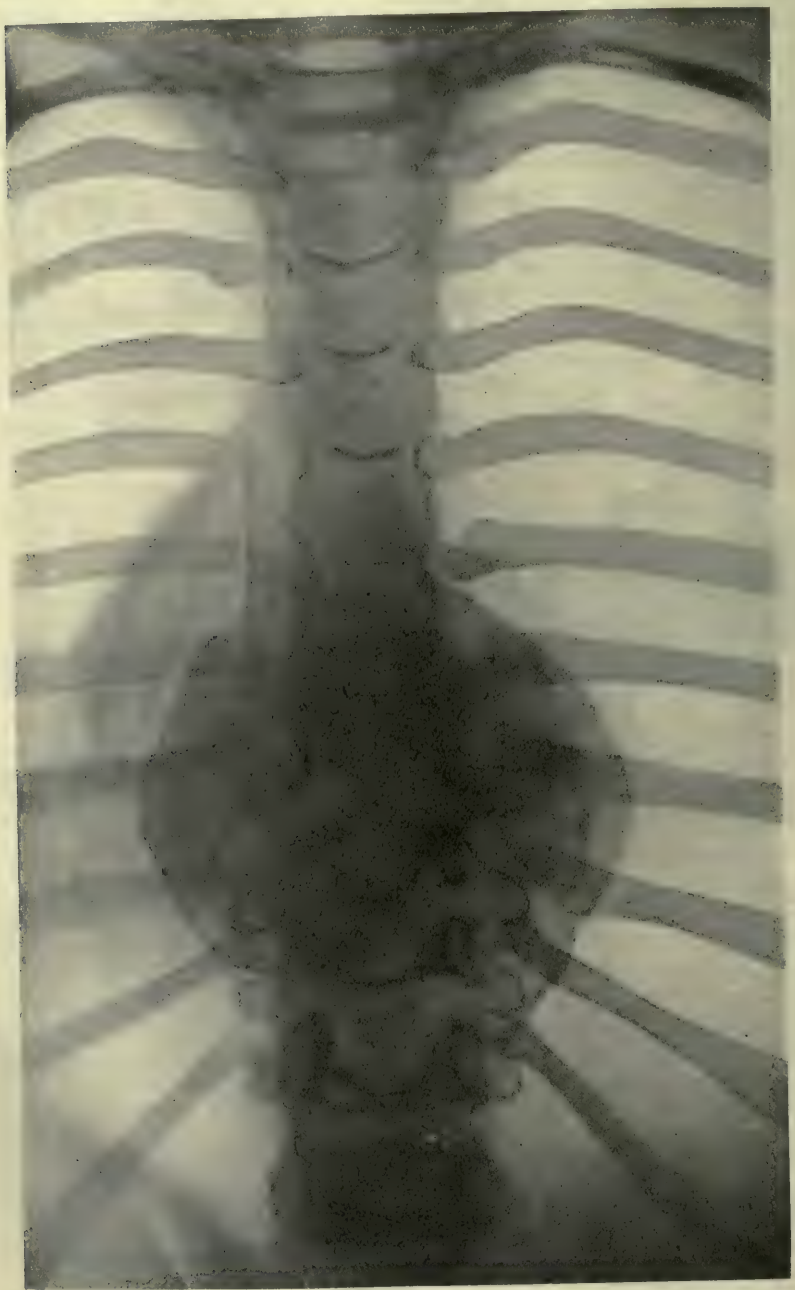


FIG. 62.—Spinal caries involving the ninth, tenth and eleventh dorsal vertebræ, with mediastinal abscess.

arisen at the time at which treatment is commenced, it can in the majority of cases be prevented; deformity which is already present may in some cases

be improved if it is not of too long duration. Secondary deformities of the chest and of the rest of the spine are frequent in cases in which there is a severe angular curve. The sternum projects greatly, forming a pigeon-breast; the ribs are raised and the chest expansion consequently diminished. If the destruction of the bodies of the vertebræ has been asymmetrical a tilt of the spine may result, necessitating a compensatory lateral curvature above or below—a true scoliosis. This secondary scoliosis is most likely to arise when the disease has been in the lumbar or cervico-dorsal regions.

*Treatment.*—The principles upon which the treatment of spinal caries is based are as follows:—(1) To reduce the deformity which has already arisen by a process of gradual hyperextension of the spine; (2) to immobilise the spine in the best position thus attainable until sufficient time has elapsed to enable the tuberculous focus to dry up, become enclosed with fibrous tissue, or become replaced by bone.

The hyperextended position of the spine has a double advantage—it tends to correct the deformity and it relieves the diseased anterior part of the spine

Fig. 63.—Gauvain's wheelbarrow splint for spinal caries.

from pressure and friction. Unfortunately adequate fixation of the spine is difficult to secure: many splints have been invented in attempting to secure it; none of them can be considered to be quite efficient, and the degree of their efficiency must depend upon the care with which they are used in individual cases. The splints which are most efficacious and which are used in England are the following:—

1. *Gauvain's wheelbarrow splint*, a wooden frame, raised from the bed board upon four legs, and across which the child lies hyperextended, the head and feet being at a lower level than the trunk. The body is secured to the frame by straps, or by a canvas jacket. A separate piece of wood forms the central part of the frame, and is padded in such a way as to press upward against the spine. This piece is removable; it forms the so-called back door of the splint. By removing it at intervals the skin of the back can be cared for, and the padding can be readjusted so as to secure the maximum degree of hyperextension and of correction of the deformity. This splint is a good one; it requires, however, very experienced and skilled nursing.

2. The *plaster bed* is a splint much used upon the Continent and now coming into favour in this country. It is cheap and easily made. The child is laid

upon his face with the head raised and supported by his hands, so that the spine is hyperextended; strips of muslin wrung out of plaster cream are then applied in succession to his back extending from the top of the head to the buttocks until a sufficient thickness is attained. As soon as it is set this plaster shape is removed; it is trimmed, and completed by the fixation of a cross-piece of wood behind the level of the shoulders. The child is secured in this bed by a few turns of bandage or with webbing straps. A thin removable mattress made of a layer of Gamgee tissue, covered with linen, is used as a lining. The advantage of this splint is that it fits the patient accurately, consequently there can be no friction and sores are very rare. In many cases it is only necessary to turn the patient to look at the back once a fortnight.

3. The *double Thomas frame* as used for spinal caries consists of two posterior metal bars extending on either side of the spine from the neck to the buttock, and thence down the back of the thighs and legs; at the upper end is a plate to receive the head, or else a bar to which a head extension can be fixed; at

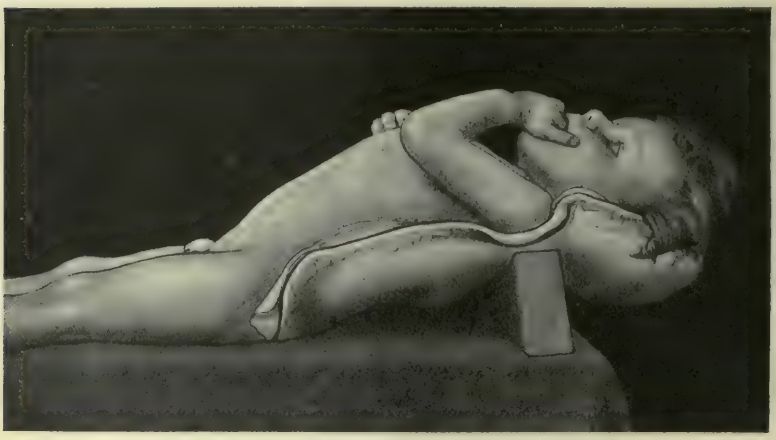


Fig. 64.—Plaster bed for spinal caries.

the lower end are foot-plates, or the leg bars can be carried into lateral bars to which leg extensions can be fixed. Two circular bars at the level of the axilla and pelvis respectively surround the trunk, and the child is secured by these and by straps. The patient lies upon a saddle fixed to the main part of the splint, and by adjusting the amount of padding in this saddle a certain amount of hyperextension of the spine can be secured.

The two last-named splints do not enable the back to be got at without disturbance. In order to care for it, it is necessary to turn the patient over; this is done carefully before the splint is removed. The splint can then be taken off, the back washed, the splint reapplied, and the patient turned back.

4. The *Bradford frame* is a simple frame of gas piping rather longer than the child, covered with a stretcher of canvas. Hyperextension is secured by bending the frame at the site of the disease.

Head extensions can be attached to any of these frames, and are required when the disease is above the level of the scapulæ. Foot extensions are similarly required if there is any tendency to flexion of the hips from spasm.

Other more simple methods of recumbency, such as simple rest on a hard bed or rest in a Phelps's box, are often used, but cannot be considered as even moderately efficient. In fact it is not possible to immobilise the spine completely in any of the forms of apparatus described; the only method which even approaches real efficiency is fixation in a plaster of Paris jacket, and this method should be utilised in every case as soon as the more acute symptoms have passed off and as soon as the deformity has been as far as possible corrected. In cervical caries it must be used from the first.

Plaster of Paris may be applied to the spine in various ways. The best is to suspend the patient by the head by means of a Sayre's sling until the weight is supported but the feet still remain upon the ground, and apply the jacket in that position. If the patient has been long recumbent he cannot be at once raised to this position; he must be prepared by preliminary tilting of his bed until he is used to the upright position. When a patient cannot be suspended he may be laid prone upon a sling of canvas and the plaster applied in this position; this is a less efficient method, and the plaster cannot be carried up to the head in this way.

A plaster jacket carried up to the head and intended to take the weight of that part may be applied in two ways. In the "Minerva" jacket the plaster is carried up to the head and is moulded around the chin, jaw, and mastoid processes. In this as in all such jackets a large window is cut over the upper part of the abdomen, to allow for respiratory movements and for expansion of the abdomen. In the "fillet" jacket the plaster is carried over the head and a strong fillet moulded across the forehead; in this way the head is held back into the plaster, and the anterior window can be cut right up the front of the chest and the front of the neck and the part immediately beneath the jaw removed; natural movements of the lower jaw are thus allowed.

At a later stage of treatment when complete immobilisation is no longer necessary, and when support is the chief requirement, a removable support may be used instead of the fixed plaster. Such a support is best made of celluloid or of poroplastic. If made of celluloid, it must be made upon a cast of the patient taken in the suspended position. If made of poroplastic, it may be moulded directly upon the patient, who should be held in the proper hyperextended position or should be suspended.

Various steel supports are utilised as convalescent splints for spinal caries; most of them are comparatively inefficient; this is specially so of such supports as do not secure a good hold upon the pelvis, and so have no proper base from which to support the spine.

The period of treatment by rest and fixation of the spine must evidently vary in different cases. The total period in the average case, including fixation upon a splint, then fixation in plaster, then support in a removable corset, will not be under three years, and in many cases much more prolonged after-support is necessary.

Throughout this period general treatment is necessary; the patient must be under good hygienic conditions, must have good food, and should if possible be kept a large part of the time in the open air. Certain localities have achieved a reputation as suitable for the treatment of tuberculosis of the surgical type. Of these Margate in England, Berck in France, and various places in Switzerland are best known. A dry, bracing climate appears to be what is required. The effect of sunlight is undoubtedly beneficial, and at various places on the Continent good results have been obtained by keeping children in splints exposed to the direct sun.

Tuberculin may be used in treatment in the same way as in other tuberculous infections; its efficacy has still to be demonstrated.

*Treatment by operation.*—The natural cure of spinal caries consists in the fixation of the diseased vertebræ together by bone. This has been demonstrated by skiagraphs and by post-mortem examinations. A recently-introduced treatment aims at securing this synostosis at an early stage by means of operation. Albee's operation consists in cutting a graft of bone from the patient's tibia by means of a circular saw worked by a motor. The diseased vertebræ having been accurately defined by means of skiagraphs, the spinous processes of these vertebræ and of the adjacent vertebra above and below are cut down upon, split into two lateral halves, the interspinous ligaments similarly split, and the bone graft then wedged in between the two lateral halves so made. In the course of three months this bone splint becomes firmly fixed in place by new bone, so that synostosis of the vertebræ results. The natural cure of the caries is thus imitated, the affected portion of the spine is fixed from within, and the period of fixation by splint or plaster necessary is thus much reduced. This operation has now been well tested. If efficiently performed it should absolutely prevent the progress of deformity, but it does not always secure a cure of the disease. This is to be expected, for the cure of the disease must depend partly upon the patient's power of resistance. It is most successful in adults, in whom it may be said to give considerably bettter prospects of cure than does treatment by simple external fixation. After the operation the patient should be kept recumbent on a plaster bed for three months, then, if there are no active symptoms, a support may be fitted which is worn for nine months. The presence of an abscess is no contra-indication unless it is in such a position as will interfere with the insertion of the graft.

Forcible correction of the deformity in Pott's disease has been suggested and carried out by Calot. It is a dangerous and irrational procedure. Not only does it open up the old tuberculous focus and so render the patient liable to a recrudescence of the disease or even to dissemination of the tuberculous infection, but if the patient escapes these dangers a gap is left in the anterior part of the spine, which if the deformity is not to recur must become filled up with bone. Although a certain amount of new formation of bone may undoubtedly be expected in the stage of cure of the disease, to expect a large gap to be filled up is irrational.

*Treatment of abscess.*—An abscess in connexion with spinal caries need not be opened immediately—in fact in many cases it need not be opened at all; it may be watched for a time, treatment by rest and fixation being carried out, and the abscess dealt with if it extends. Two alternative methods are then possible. The abscess may be aspirated, or it may be opened, washed and swabbed out thoroughly, and closed again; on no account should it be opened and drained.

Aspiration is the method most generally adopted; it must be carried out with a large-bore needle fitted with pointed and blunt stilets and with a good glass syringe. The needle is inserted in the the abscess through a good thickness of healthy tissue and the contents withdrawn by suction. If the abscess contains caseous matter which is too thick to allow of its passage through the needle, it may be modified by the preliminary injection of an ethereal solution of camphorated thymol. Gauvain's solution for this purpose consists of 1 part of thymol, 2 parts of camphor and 3 of ether; from 2 to 5 cubic cm. of this are injected through the syringe. Aspiration does not require an anæsthetic; it must be repeated as often as is necessary

until the abscess no longer refills. If the cavity continues to refill and requires repeated aspiration, iodoform may be injected. A 5 per cent. solution of iodoform in ether is used, 5 cubic cm. being injected through the syringe, which must be retained in place until the ether has evaporated in the abscess and its vapour escaped through the needle. A deposit of iodoform upon the walls of the abscess results, and this causes an inflammatory reaction with at first an increase in the quantity of pus, but subsequently a great diminution in this and a tendency for the abscess to dry up.

If an abscess is to be opened, this must be done with the most careful aseptic precautions, the contents evacuated, the tuberculous granulation tissue forming the walls of the abscess rubbed away with swabs of gauze, and the cavity thoroughly irrigated with weak iodine, the abscess being then carefully sutured. Abscesses should be opened in the region at which they point, but if possible through healthy skin. The special methods of opening deep-seated abscesses, such as that devised by Treves for opening a psoas abscess by a lumbar route, no longer find a place in surgery.

The infection of an abscess or of a sinus connected with caries of the spine with septic micro-organisms such as the streptococci or staphylococci is a most serious matter; it very greatly increases the risk of a fatal termination to the disease. If such a septic infection has arisen the sinus is best treated by a thorough cleansing of its interior by rubbing with swabs soaked in Morton's fluid (iodine 10 grains, potassium iodide ½ drachm, glycerin 1 ounce), the sinus afterwards being protected with dry dressing and no drain or plug used.

Retro-pharyngeal abscess occurring as a complication of cervical caries should be treated by aspiration through the side of the neck; it must on no account be opened through the pharynx.

*Paraplegia.*—Paralysis as the result of pressure upon the spinal cord is an occasional incident in Pott's disease. It may occur in disease at any level, but is most frequent when the mid-dorsal region is attacked. This complication is more serious if the disease is high up, and is very much more serious in adults than in children.

The first indication of paraplegia is usually a slight dragging of the feet, causing a shuffling gait; upon examination it is then found that there is exaggeration of the knee-jerks and some inco-ordination and perhaps spasticity of the lower limbs. If the condition progresses a complete spastic paraplegia develops, the legs becoming spastic, the deep reflexes increased, the superficial reflexes lost, and the plantar response becoming extensor. Some loss of control of the bladder is frequently an early sign, but complete loss of the vesical and rectal reflexes occurs only in the worst cases. Loss of sensation is a late event, and is found only in cases of exceptional severity.

The pressure upon the cord is usually due to an abscess or collection of caseous material projecting behind the bodies of the vertebræ into the vertebral canal. It is very seldom due to actual pressure by bone; hence it is not necessarily in the cases with severe deformity that paraplegia arises —indeed, in adults paraplegia is sometimes found without any external deformity at all.

Paraplegia in the majority of cases requires no special treatment other than fixation of the spine and proper nursing. In children such treatment with the spine held in a properly hyperextended position results in the spontaneous disappearance of the paralysis in almost every case. Laminectomy as an attempt to relieve the spinal cord from pressure is only indicated in

cases which have been treated by fixation for a long period (one year or more); it is more often indicated in adults than in children, and may be justified by the presence of a complete paralysis with sensory loss.

### Other Infections of the Spine.

**Acute staphylococcal infection of the spine** is rare. It is characterised by the general symptoms of osteomyelitis, and, although there may be severe

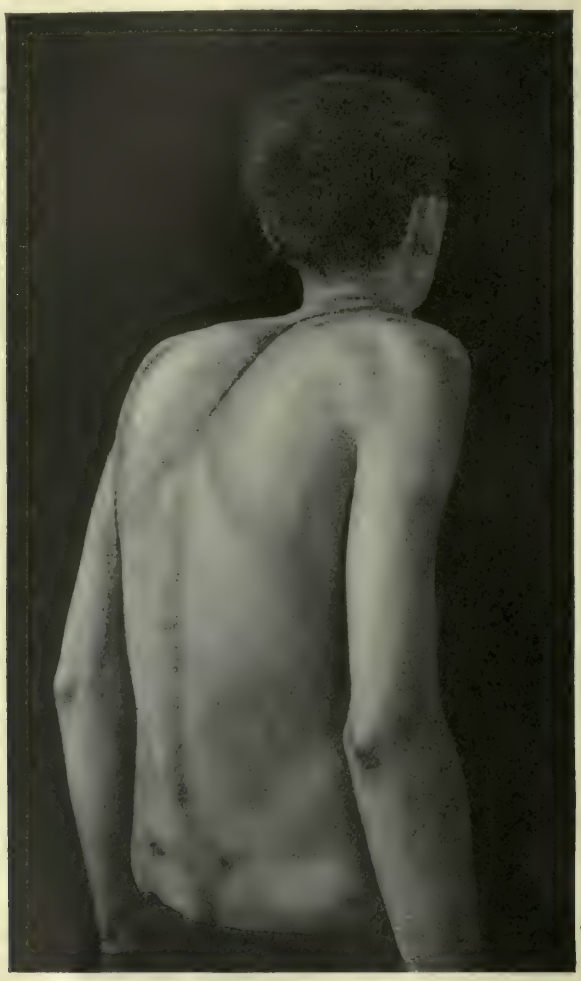


FIG. 65.—Spondylitis deformans.

pain and the spine may be rigid, the localising symptoms are usually not very evident. The disease is a pyæmic infection and usually fatal.

**Subacute septic infection of the spine** without external suppuration may occur as a sequel of one of the infectious diseases. In such cases after an acute illness with high temperature a localised sharp curve appears in the spine, directed either backward or to one side. A skiagraph shows blurring of the affected vertebræ and subsequently synostosis between them. During

the acute stages rest is required; the difficulty in such cases is to exclude tuberculous disease. At first the disease must be treated as if tuberculous; but if rapid recovery takes place, and if the formation of new bone as shown in the skiagraph appears more than would be expected in a tuberculous process, massage, manipulations and exercises may be used to attempt to restore mobility. This form of spondylitis occasionally complicates typhoid fever, occurring either during convalescence or after recovery. It appears to be an actual infection of the vertebræ with the typhoid bacillus.

**Spondylitis deformans.**—Spondylitis deformans is a chronic inflammation of the spine occurring chiefly in adults, and characterised by progressively-increasing kyphosis with loss of mobility of the spine, ending in ankylosis. The condition during the progressive stages may be acutely painful, the pain being referred along the spinal nerves.

The pathological changes found are—(1) an ossifying periostitis of the surface of the vertebræ ending in the actual union of the vertebral bodies or laminæ to each other by new bone; and (2) osteoarthritic changes in the intervertebral joints with the production of osteophytes around. In some cases these changes are local in the spine, in others they are associated with changes in the joints. The hip joints are most commonly affected, the shoulders next. In these joints a progressive painful rigidity arises and ends often in ankylosis. The name of *Spondylose rhizonelique* has been given to this condition by Marie.

Spondylitis deformans is due to a septic infection of the spine with organisms derived from a septic focus in some part of the body. In many cases the condition is undoubtedly due to a gonococcal infection of the spine, in others it is due to infection from the mouth (pyorrhœa); no doubt other foci of infection can give rise to the condition also. Similar changes in the spine are found in osteitis deformans.

The diagnosis from simple kyphosis is made by the rigidity, from spinal caries and localised infective spondylitis by the extent of the disease over more or less the whole length of the spine, and by means of a skiagraph.

The first step in treatment is to discover and cure any primary focus of infection. During the painful stage the spine must be kept at rest by means of a support and counter-irritation over the spine carried out for the relief of pain. As soon as all acute symptoms have disappeared massage and manipulations may be carefully commenced, in order to attempt to restore mobility, and particularly to restore the lumbar concavity if, as is often the case, this has been abolished. Manipulations should not be pushed to the extent of producing acute pain and should not be used until active symptoms have disappeared.

## Deformities of the Neck.

Congenital malformations of the cervical vertebræ, corresponding in type with those already described in general, occur. The most frequent are—the occurrence of cervical ribs attached to the seventh cervical vertebra, the asymmetry of the cervico-dorsal region of the spine named *congenital elevation of the scapula*, and *cervical spina bifida*. Spina bifida is described under *Diseases of the Vertebral Column*; congenital elevation of the scapula under *Deformities of the Trunk*; and cervical rib in Section VII.

**Torticollis.**—Torticollis is a condition in which the head is held awry; it occurs from several causes, and may be purely symptomatic. It is, however, convenient to include these several conditions together. Torticollis may be simply a habitual posture, there being no fixed deformity or structural defect,

or it may be due to spasm of certain cervical muscles, or it may be due to contracture of these muscles, or to deformity of the cervical vertebræ. In one particular class, spasmodic torticollis, the condition is intermittent and not constant.

**Congenital or sterno-mastoid torticollis.**—That deformity of the cervical spine which results from shortening of one sterno-mastoid muscle is usually named *congenital torticollis*. This is not a completely satisfactory name, for in many cases there is no evidence that the condition is present at birth. In fact, although in a few instances children with this defect are brought for treatment in infancy, it is much more common for the deformity to be noticed at the age of seven to ten years.

FIG. 66.—Sterno-mastoid torticollis.

The position assumed by the head if the left sterno-mastoid muscle is contracted is as follows. The head is tilted towards the left shoulder, rotated towards the right, and the chin slightly elevated. If the obliquity of the head is corrected either voluntarily or by manipulation, it is then found that the whole head is displaced towards the right. The sterno-mastoid muscle may appear normal in appearance and to touch, but in severe cases it is usually smaller than on the sound side and feels hard. In such cases the muscle is in part converted into a hard strand of fibrous tissue. In most instances of sterno-mastoid torticollis there is some asymmetry of the face, the side upon which the muscle is contracted being smaller. This asymmetry may be present at birth, but is more commonly noted when the torticollis is of old standing.

A secondary lateral curvature of the spine occurs in torticollis; if the left muscle is shortened, there is a convexity in the cervical region towards the left, and a compensatory curve in the dorsal region towards the right. This curve is as a rule postural, there is no fixed deformity, and if the torticollis is cured the spinal curve will soon disappear.

The pathology of sterno-mastoid torticollis is not definitely ascertained. It is clear that the actual defect is a shortening of the affected muscle from fibrosis. This may be ascribed to—

1. Primary developmental defect;
2. Position or pressure in utero;

3. Injury of the muscle at birth, with subsequent contraction;
4. Inflammation of the muscle at or soon after birth, with subsequent contraction.

In favour of the first-named suggestion is the fact that in some cases there are associated deformities, and that occasionally torticollis may be found in more than one member of a family.

In favour of birth injury as a cause is the fact that a history of difficult labour is frequent, and in some cases there is a clear history that a swelling was noticed in the sterno-mastoid after birth (*hæmatoma*). On the other hand, it is not usual to find a muscle undergoing shortening and fibrosis after an injury if there is no septic infection, and in many cases a child with a sterno-mastoid hæmatoma has been watched and no tendency to subsequent torticollis has been found.

The pathological condition found in the muscle is in favour of the theory of an inflammatory origin; in certain cases the sterno-mastoid tumour found soon after birth is probably inflammatory, and in some it is undoubtedly a gumma. Beyond this there is in the majority of cases no history of any inflammatory attack in the muscle. A similar torticollis with contraction of the sterno-mastoid and asymmetry of the face may arise in older children after an attack of cervical adenitis.

Finally, it has been suggested that the contraction is the result of some nerve affection with subsequent contracture of the paralysed muscle. This, however, seems very improbable; a paralysed muscle in any other situation does not tend to become contracted, but rather to be overstretched.

*Treatment.*—When the torticollis is discovered in infancy daily manipulations to stretch the shortened muscle will in most cases effect a cure. In older children, however, operation is necessary. This consists in tenotomy of the sterno-mastoid, complete correction of the deformity, and subsequent treatment either by fixing the head in the over-corrected position or by daily manipulations. The tenotomy is usually carried out by an open incision for these reasons—first, that on account of the close proximity of important vessels it is difficult to divide completely both heads of the muscle close to its lower attachment, the only position at which subcutaneous operation is possible; and secondly, because there is always at this point a dense contraction of the sheath of the muscle which cannot be divided subcutaneously. Nevertheless it is possible with care to divide both heads with sufficient accuracy, and if the head is then well stretched over-correction can be secured in many of the slighter cases. The subcutaneous operation has the advantage of leaving no scar—often a matter of considerable importance in girls. The open operation is essential in severe cases. Some operators prefer to divide the muscle at its upper attachment, others in the middle of the neck. Both these operate by the open method.

If it is possible to secure daily manipulations to stretch the muscle after operation, these will be sufficient to prevent recontracture. These manipulations must, however, be accurately carried out. For a right torticollis the manipulation is carried out as follows. The patient sits upon a stool with the back to the operator; the shoulders must be kept level throughout. The head is first forced towards the right, then tilted to the left, and then rotated so that the chin points upward and to the right. By these movements the right sterno-mastoid is fully stretched. If such manipulations cannot be managed the head must be fixed immediately after the operation in the over-corrected position either in plaster of Paris, or in some form of collar, and this apparatus must be maintained for a period of at least three months.

**Acute and secondary torticollis.**—Acute torticollis is due to spasm of some of the cervical muscles, most often of one sterno-mastoid, or of the splenius. The latter muscle by its contraction produces the same deformity as would the sterno-mastoid of the opposite side. Acute torticollis is most often due to some inflammatory lesion in the neck which produces spasm of the neighbouring muscles, so that it is a secondary or symptomatic deformity. It is most often due to inflamed cervical glands or to spinal caries. It differs from the form already described in that it is painful.

An acute wry-neck should lead to a careful investigation of the cervical and upper dorsal spine, of the cervical glands, and of any site from which the latter might be infected (tonsils, teeth, scalp, etc.). If affections of the spine and glands are excluded, the deformity may be ascribed to a myositis of the affected muscle (*rheumatic torticollis*).

An acute torticollis requires no local treatment; it disappears as soon as the primary cause has been removed.

**Spasmodic torticollis.**—This is a particular form of torticollis due in the first place to spasm of the sterno-mastoid muscle, in which the cause is probably in the central nervous system.

The patients are usually adults. There is a constant spasm of certain muscles, with a superadded series of clonic contractions, so that the head is never still. Although at first these symptoms may be confined to the sterno-mastoid muscle, in many cases they become generalised, the patient holding himself in the most extraordinary attitudes, and the whole of one side of the body being perhaps affected. The clonic spasms are accompanied by severe pain; they usually disappear during sleep. Nothing is known of the pathology, but the disease appears to be one of the central nervous system, and is certainly not a local affection.

*Treatment* is very unsatisfactory. General treatment by isolation, complete rest, and later muscle training exercises must be tried. Division of the affected muscles or of their nerves (*e.g.*, of the spinal accessory) has been advocated, but is not successful; and in fact, as the condition is a generalised one, little can be expected of such local treatment.

**Habitual torticollis.**—Some children habitually hold their heads on one side in an attitude simulating that of torticollis, but upon examination it is found that there is no contracted muscle and no resistance to an attempt to straighten the neck. Such children should have their vision carefully tested, as the condition is often due to a visual defect which they have found to be minimised by the attitude they assume (*ocular torticollis*).

**Torticollis of bony origin.**—Torticollis may arise as a result of asymmetry of some one or more of the cervical vertebræ; this may be due to a congenital defect, or may have arisen as the result of asymmetrical destruction of the vertebræ by spinal caries. One special form of torticollis of bony origin must, however, be mentioned.

**Subluxation of the cervical vertebræ.**—A partial dislocation of two vertebræ about the middle of the cervical region is an occasional accident which results from muscular violence. It may follow comparatively slight sudden movements of the head, and has occurred during sleep. If the articular process of one vertebra is dislocated forwards upon that beneath it, the head is both tilted and rotated towards the opposite side. If the displacement is more complete, so that the articular process of the upper vertebra can drop down in front of that of the lower, the head is rotated towards the opposite side but tilted towards the affected side. In either case there is an alteration in the proper alignment of the spinous processes and a tender mass of muscles over

the region of the dislocation. These signs together with the history of a recent acute onset will serve to differentiate the condition from the other varieties of torticollis. This injury resulting from muscular violence differs from the dislocation of the cervical spine which results from more severe injuries in that paralysis is practically never present. The subluxation has been reduced in several instances by the following manipulation. Under an anæsthetic the head is pulled strongly backwards and away from the injured side, so as to disengage the articular processes; it is then rotated so as to bring the vertebræ into place.

## Deformities of the Trunk and Thorax.

Many deformities of the thorax are secondary to some malformation of the spine. Those remaining include congenital defects of the clavicle, ribs and sternum, that congenital deformity known as *elevation of the scapula*, and rickety deformities of the chest.

**Absence or defect of the clavicle.**—The clavicle may be altogether absent, or it may be represented by its inner extremity only. The deformity is rare, is usually symmetrical, and leads to very little disability. It results in a remarkable mobility of the shoulders, so that these may be pressed forwards until they touch anteriorly. This deformity is part of a general defect in the development of those bones which are formed in membrane. The bones of the cranial vault ossify slowly, with, during childhood, large membranous gaps in between. The anterior fontanelle may remain open up to adult life; the bones of the face are small. The defect (*cranio-cleido-dysostosis*) is a rare one, and shows a strong tendency to occur in families. It requires no treatment.

**Congenital defects of the ribs.**—The ribs may be increased in number by the presence of ribs attached to the last cervical or to the first lumbar vertebræ, or they may be diminished by the first dorsal or twelfth dorsal being absent or rudimentary. Bifid ribs bifurcating at a short distance from their vertebral attachments are a usual accompaniment of congenital elevation of the scapula. Occasionally two of the upper ribs are united by a vertical bony bar near their attachments to their cartilages, and this bar may be prominent and be taken for a growth or inflammatory affection. All these rib defects are diagnosable only by means of skiagraphs.

The sternum is developed from a series of pairs of centres of ossification; it may be bifid by incomplete fusion below, or may contain an aperture by incomplete fusion in the central part. The central part of the sternum may be depressed (*funnel chest*). It is a congenital deformity, and is only of importance on account of the associated defective chest expansion; it may be improved by breathing exercises, but not cured.

The rickety deformities of the chest have been described under *Rickets*.

**Congenital elevation of the scapula (Sprengel's deformity)** is a general congenital defect of the upper part of the spine and thorax, of which the most evident sign is the elevation and imperfect mobility of the scapula. Many variations of the deformity occur, but the clinical picture in a typical unilateral case is as follows. The scapula is smaller than that of the opposite side, is situated at a higher level, and is tethered to the spine, so that elevation of the arm is incomplete, the scapula failing to rotate. Between the scapula and the spinous processes may be felt a hard mass apparently of fibrous tissue, or a small piece of cartilage or bone. The spinous processes of some of the upper dorsal vertebræ deviate towards the affected side, forming a sharp

lateral curve. The ribs on the affected side are often flattened in the axilla. Skiagraphs show that the vertebræ are asymmetrical; there may be a wedge-shaped vertebra or an extra half-vertebra. The ribs are also asymmetrical; two ribs may arise from one vertebra, or a rib may bifurcate at a short distance from the spine, or one or more ribs may be absent. The skiagraph may also show the extra bone between the scapula and the spine, which is usually attached to one or more of the upper dorsal laminæ. In bilateral cases, which

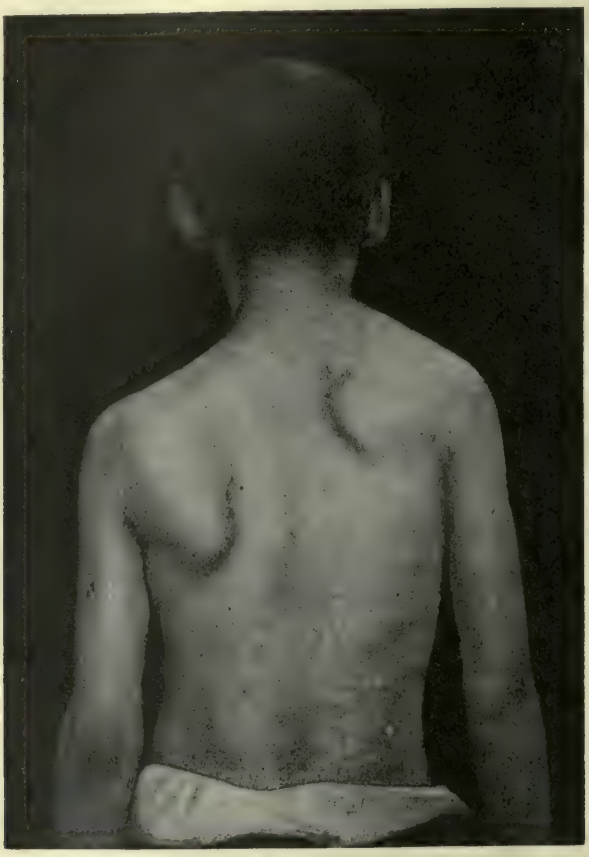


FIG. 67.—Congenital elevation of the right scapula. Sprengel's deformity.

are rare, the cervical region of the spine is very short and broad, and there is much limitation of mobility of the arms.

The defect is thus a general one in the development of the upper thoracic segment. It may require treatment by removal of the extra bone between the scapula and spine, by section of the fibrous tissue lying in this situation, and by manipulations and exercises to increase the mobility of the scapula.

## Deformities of the Upper Limb.

**Congenital deformities.**—Congenital dislocation of the shoulder is of such doubtful occurrence that the condition does not merit description. Most if not all of the congenital dislocations that have been reported have been

subluxations backwards; in most cases, if not in all, this has been secondary to paralysis; this paralytic type of subluxation is described under *Obstetrical Paralysis.*

At the elbow the only congenital deformity occurring at all frequently is a forward displacement of the head of the radius; this is usually overlooked until later childhood; if any disability results the treatment consists in resection of the head of the radius.

*Congenital club-hand* is a rare deformity, much more rare than the corresponding deformity of the feet. It occurs in several different types, of which the principal are:—

Radial club-hand, in which the whole of the radius or its lower part is absent; the hand is deflected towards the radial side, and the thumb is often missing.

Ulnar deflection of the hand, the fingers being flexed and the thumb adducted into the palm.

In these treatment must be by manipulations, splinting, and the eventual use of a supporting apparatus. In a few cases operations to replace the radius by splitting the ulna have been performed, but there are no reports of end results.

Other congenital deformities of the whole arm occur, but are too rare to merit description.

The congenital deformities of the fingers have already been described (see section on *Congenital Deformities*), but certain points in their treatment require mention.

Supernumerary digits in the hand should as a rule be removed. It is as well if possible to wait until the child is two years old or even older, particularly if there is any doubt as to which of two digits is the more useful. It is then possible to dissect the digit away carefully, straighten up the remaining digit if necessary, and preserve muscle attachments if these are attached to the digit which has been removed. For example, if there is a supernumerary thumb dividing at the metacarpo-phalangeal joint, the radial digit is that which will require removal, but it may have some of the short muscles of the thumb attached to it, and these must be preserved and fixed to the first phalanx of the true thumb.

Webbed fingers are also best left during infancy and operated upon at the age of three or four. The best method of operating is to take a flap from the palmar surface of one finger and from the dorsum of the other; the fingers are then separated and the flaps lightly stitched to the finger to which each is attached, a V-shaped flap with its base upwards being taken from the dorsum and fixed between the roots of the fingers. If too large a flap is taken, or if an attempt is made to sew the flaps down tightly, sloughing may occur with disastrous results. Every case must be treated in accordance with the condition found, and it may be necessary to use most of the skin for covering one finger, leaving the other to granulate over and become in consequence stiff.

## Defective Growth of the Bones of the Upper Limb.

**Defective growth of the upper epiphysis of the humerus** is not very uncommon as a sequel of epiphysitis; it is important in that it may cause considerable shortening of the arm, this being the chief growing epiphysis of the humerus. But deformity does not arise, the growth remaining symmetrical.

**Defective growth of the lower epiphysis of the humerus.**—This epiphysis is of little importance in growth, and consequently no severe deformity arises

if it is injured. Normally the humerus and the bones of the forearm make an angle of 170 degrees opening outwards (carrying angle). Alterations in this angle are not uncommon. If the angle is decreased, the condition resulting is known as *cubitus valgus;* if it is converted into an angle opening inwards, the condition is known as *cubitus varus.* The latter is the more frequent and the more important, as the carrying angle is destroyed. Cubitus varus results from an injury to the lower end of the humerus. It may be due to actual malposition of the fragments after a fracture in this situation; more frequently, however, it develops later gradually. In such cases it is probable that the epiphyseal line has been injured by an oblique fracture, growth is rendered unequal upon the two sides as a result, and the deformity then arises. Cubitus varus and valgus as a rule call for no treatment, although in exceptional cases, if there is any disability, an osteotomy may be performed.

**Defective growth of the lower epiphyses of the radius and ulna.**—These epiphyses are of great importance, growth at them giving rise to most of the

FIG. 68.—Spontaneous subluxation of the wrist. Madelung's deformity.

increase in length of the forearm. Defective growth of the radius is not uncommon after separation of the lower epiphysis; as a result the ulna usually projects downwards on the inner and dorsal aspect of the wrist, the hand being displaced outwards and forwards. Defective growth of the ulna may also follow injury or epiphysitis. When the ulna fails to grow properly the radius may extend down beyond it carrying the hand with it, or if the lower end of the ulna remains attached to the wrist the head of the radius may be dislocated forwards. This is one of the epiphyses most often affected in cases of multiple exostoses.

**Spontaneous subluxation of the wrist (Madelung's deformity).**—This is a deformity of the wrist arising in adolescents, more common in girls than in boys, and unilateral and bilateral with about equal frequency. The affection arises with attacks of pain in the wrist following work. The hand and carpus become displaced forwards, the lower end of the ulna projecting upon the dorsum of the wrist. The lower end of the radius is concave forwards, so that an alteration is brought about in the direction of its articular surface. The styloid process of the radius is at a higher level than that of the ulna. The lesion is a partial arrest of growth of the lower epiphysis of the radius, growth

being more rapid upon the outer and posterior aspect of the bone than upon the inner and anterior aspect. Abnormality of part of the epiphyseal line can sometimes be demonstrated in skiagraphs. This interference with growth is in some cases due to a definite injury; it appears, however, to be more often due to repeated slight injuries occurring as the result of some particular occupation. As the deformity is often bilateral and has occurred in more than one member of a family, it is possible that there is an original defect of this epiphysis in some cases.

When the deformity is found to be arising during adolescence, an attempt to stay its progress should be made by the application of a splint to be worn at night. In well-established deformity, if there is any disability or if the deformity is considered to be unsightly, it may be improved by osteotomy of the radius at a low level.

## Paralytic Deformities of the Upper Limb.

The deformities of the upper limb due to infantile paralysis and to spastic paralysis have been already sufficiently described. Two special paralytic deformities of the upper limb require mention.

**Obstetrical paralysis (Erb's paralysis).**—By this is meant a paralysis involving a greater or less portion of the upper limb and resulting from an injury to the brachial plexus during labour. It occurs usually after difficult labour when traction has been made upon the head, or in breech cases when traction has been made through the shoulders. The actual injury is probably a forcible separation between the head and one shoulder, and a similar paralysis may be acquired at a later age as the result of such an accident, the head being pressed to the opposite side whilst the shoulder is forcibly depressed.

In true obstetrical paralysis the injury is manifest immediately after birth, the affected arm hanging powerless. Upon examination it is found that the deltoid, biceps, brachialis anticus, triceps and the supinator and extensor muscles of the forearm are paralysed. The subscapularis, spinati, and teres minor are also paralysed, but their loss of power is more difficult to determine; other muscles may be affected, in the most severe cases the whole arm being completely paralysed, but the distribution given above is that which is typical of the majority of cases.

A very characteristic position results from this paralysis: the arm hangs by the side with the elbow extended, the forearm pronated, the wrist flexed, and the whole limb rotated inward. At first the limb is quite flaccid, but after a short time, sometimes after only three or four weeks, first rigidity, then actual contraction, arises in those muscles which are not paralysed or which have recovered. The result of this is that the limb is now held stiffly in the position already described, and when actual contraction has taken place it may be impossible without exerting excessive force to carry out certain movements. The movements which are specially affected and lost are external rotation and abduction at the shoulder, supination of the forearm, and extension of the wrist. The limitation of movement at the shoulder is due to contraction of the pectoralis major, and particularly of the subscapularis, in which power returns early; the contraction of the latter muscle not only rotates the arm inward, but also partially dislocates the head of the humerus, so that it lies upon the posterior margin of the glenoid cavity. This subluxation constitutes the condition formerly described as congenital dislocation of the shoulder; it may be produced in quite a short time after

birth, and once arisen persists even after all the paralysed muscles have recovered.

The actual lesion in Erb's paralysis varies. In most cases there is only a partial rupture of the trunk formed by the fifth and sixth cervical nerves, or even merely a rupture of its sheath; occasionally in more severe cases the lesion may be more extensive, amounting even to the tearing of some of the nerve roots away from the cord.

In a very large proportion of cases a natural return of power in the affected muscles may be expected. In some cases this is rapid and occurs before any contraction has arisen; more often it is slow but evident within two to three months; in rare cases there is no return of power. In those cases which recover rapidly there is probably a rupture of the sheath with pressure upon the nerve by hæmorrhage; in those which recover slowly a limited injury to the nerve itself; in those which do not recover a more serious injury to the nerve, which may in these cases be torn away from the cord.

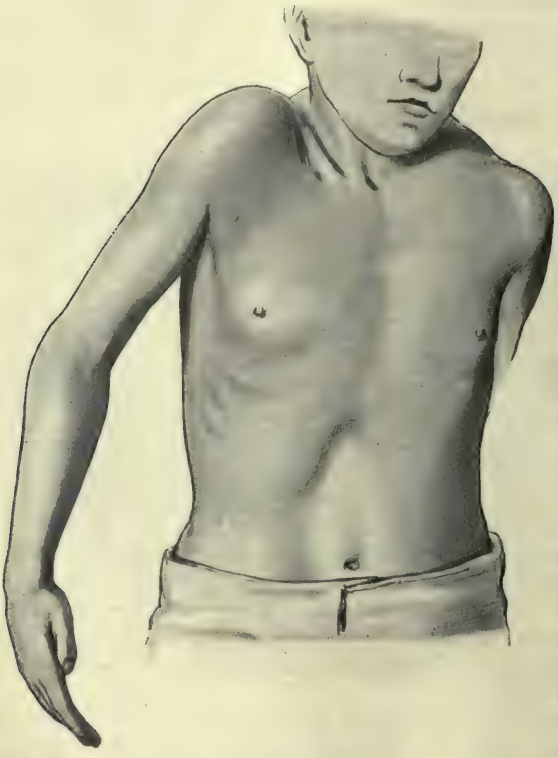


FIG. 69.—Erb's paralysis. The patient is endeavouring to abduct and externally rotate the arm, movements which are impossible on account of contracture.

*Treatment* in cases seen early has as its chief object the prevention of contraction. At as early as possible a date the limb should be fixed upon a splint with the shoulder abducted to a right angle and fully rotated out, the elbow flexed, the forearm supinated, and the wrist extended. This splint must be retained day and night and removed only for daily massage and manipulations. If recovery has not commenced at the end of six months' treatment operative interference is justifiable, but the chance of improvement by means of it is small. The child should be anæsthetised and electrical examination carried out; if any response to a faradic current is obtained in the affected muscles, operation should be postponed, for recovery will ensue. Only in cases in which there is no faradic response is operation indicated. In them the brachial plexus may be explored. If an actual tear is found in the upper trunk it should of course be refreshed and sutured, but it is the exception to find this. If no tear is found, the nerve should be freed from scar tissue and its sheath incised longitudinally in order to relieve pressure. In some cases where there

appeared to be a complete lesion of the upper trunk of the plexus in an inaccessible situation the trunk has been divided and its lower end implanted into the seventh cervical nerve, but no good results have been reported.

In old-standing cases when contraction has taken place the first step is to overcome the deformity. For example, if the wrist is found to be permanently flexed, the application of a splint with daily massage and manipulations will rapidly restore full extension, and the extensor muscles which are present but have not recovered their full power because they are overstretched will soon become strong. When subluxation of the shoulder-joint is present there is considerable disability; the arm cannot be everted or raised from the side, although the external rotators of the arm and the deltoid are found to be present and reasonably strong. In such cases an attempt may be made to replace the head of the humerus in the glenoid cavity by manipulation under an anæsthetic, but this is not likely to be successful in any but recent cases. In these cases of subluxation Fairbank advises an open operation upon the shoulder-joint, the anterior part of the capsule, including the attachment of the subscapularis, the coraco-humeral ligament and the supraspinatus being divided, and the arm being fixed in a fully everted position in plaster. Considerable improvement in the mobility of the shoulder-joint follows this operation, but power of abduction does not return. The position already described for fixation of early cases appears to be a better one for use after operation than that of simple eversion advised by Fairbank.

**Tendon transplantation in the upper limb.**—In cases of paralysis of the upper limb with a limited distribution it is often possible to restore functional use by transplanting certain muscles or tendons and altering their action. This is true both of infantile paralysis and of cases of paralysis due to injury of the peripheral nerves in which suture of the nerve has been impossible or in which suture has not been followed by any recovery. Each case must be considered individually. The first step is to consider what actual movements we wish to restore, and whether there are any muscles available which can be spared from their original action and put to the new use. The next step is to consider whether these muscles can be brought into a satisfactory line to their new insertions. To take a common example, in a paralysis due to a complete lesion of the musculo-spiral nerve below the origin of the branches to the triceps, the patient is unable to extend his wrist, the metacarpo-phalangeal joints of his fingers or any joint of the thumb. As extension of the wrist is an essential part of the action of gripping an object, his grip is very weak; moreover, it is impossible for him to open out the fingers and thumb in order to seize the object. A certain number of other muscles can be spared to replace the extensors, but these are not sufficient to allow of a muscle being transplanted into each of the lost muscles individually. Therefore it is best to decide that an attempt be made to enable the patient to extend the wrist voluntarily, and to extend the thumb and fingers together so as to open the grip. A wrist extensor can be supplied by fixing the tendon of the pronator radii teres into the extensor carpi radialis longior and brevior, which lie directly over it. As a rule there are three flexors of the carpus, the flexor carpi radialis, flexor carpi ulnaris and palmaris longus. Two of these can be spared; the flexor carpi radialis and palmaris longus are the best to use for transplanting because they are tendinous for a considerable distance and so can be brought into a good line. It is usual to fix the former into the extensor longus pollicis and into all the extensors of the fingers, and the palmaris longus into the extensor ossis metacarpi pollicis and extensor brevis pollicis. This method has the additional advantage that the flexors of the wrist com-

monly act with the extensors of the fingers and thumb, and that therefore re-education of movement is simplified. In performing the operation the transplanted tendon is freed from its insertion and separated sufficiently high up the forearm to enable it to take a straight line to its new attachment; it is then passed through a slit in the tendon to which it is to be fixed, which is left intact. The hand and fingers and thumb are held fully extended and both the tendons pulled as tight as possible whilst the suture is being made. The limb is fixed afterwards upon a splint which supports the hand, fingers and thumb in the fully-extended position, and this is retained for six weeks. At the end of this time the patient must be shown how to make use of the transplanted muscles. By this transplantation a hand which is almost useless can be restored to a very considerable degree of power.

Sometimes in a more limited paralysis it is possible to transplant a muscle to replace each of those lost. For example, if only the three extensors of the thumb are lost they can be replaced by inserting into them the extensor carpi radialis longior, the supinator longus and the palmaris longus.

**Drop finger (Mallet finger) is** a condition caused by a blow upon the terminal phalanx of the finger, or by some other force which suddenly flexes this phalanx. The expansion of the extensor tendon which is attached to the terminal phalanx is partially or completely ruptured. The last phalanx of the finger hangs in a permanently-flexed position.

*Treatment* consists in fixation of the finger upon a splint which keeps the last phalanx hyperextended. In a recent case such fixation for a fortnight should result in reunion of the tendon; in old-standing cases several weeks' fixation is necessary before the tendon becomes shortened. Operation is unnecessary.

## Deformities of the Lower Limb.

### Congenital Deformities.

**Congenital dislocation of the hip.**—Congenital dislocation of the hip is one of the commonest of congenital deformities. It occurs much more frequently in girls than in boys, about 88 per cent. of the cases being girls; it is most often unilateral, the proportion of unilateral to bilateral cases being about 2 to 1.

Nothing is known as to the etiological factors. There is no doubt that the dislocation is present before birth. It is a developmental malposition, but the stage of development at which it is produced is not known. In some cases a hereditary influence may be traced, and in others two or more of the same family are affected. But most instances occur sporadically in one member of a family the other members of which are normal. Occasionally congenital dislocation coexists with other deformities, such as club-foot, hare-lip, cleft palate or spina bifida, but this is the exception.

*Pathological anatomy.*—The condition of the structures forming the hip-joint varies in different cases and also according to the age at which they are examined. At birth the acetabulum is present and fairly well developed, although shallow. It is lined with cartilage, the ligamentum teres is present, the capsule is well formed, and the head of the femur lies in an extension upwards of this capsule. The communication between the capsule and the original joint is as a rule at the lower and posterior part of the acetabulum. The head of the femur is well formed and covered with cartilage; the femoral neck may be short, perhaps depressed and perhaps twisted, so that the neck of the femur in relation to the shaft points more forward than usual. Thus

Plate 2.

Congenital dislocation of the right hip from in front. (Skiagram taken by Dr. Hugh Walsham.)

at birth the structures of the joint show evidence of good development, indicating that in all probability the hip-joint is developed normally up to a certain time, and that then, dislocation occurring, the further development of the acetabulum and of the femoral head is affected. In joints examined at later ages further alterations are found. The acetabulum becomes comparatively shallow; its rim, particularly in the upper part, is wanting; its cartilaginous lining becomes fibrous. The ligamentum teres becomes flattened, thinned, and may disappear; the communication in the capsule between the original and the false joints is narrowed, and the capsule may be found adherent to the upper margin of the acetabulum. The head of the femur is flattened and altered in shape so as to fit more accurately upon the ilium, where a depression may be found, formed by the pressure of the femoral head and acting as a false acetabulum.

In a large proportion of cases the head of the femur rests upon the dorsum ilii at a varying level above and behind the acetabulum. In a few cases, however, it rests against the ilium immediately below the anterior superior spine. These constitute the anterior type of dislocation; in them the communication between the true and false joints may be situated at the upper part of the acetabulum. It has been suggested that most dislocations are originally anterior, but that when the weight is borne upon the limb the head of the femur slips further upward and backward upon the dorsum ilii. This is not probable, first because of the usual low posterior site of the communications between the true and false capsules, and secondly because when a posterior dislocation is reduced by manipulation to an anterior one the head of the femur usually remains in the anterior situation and does not tend to slip back on to the dorsum ilii.

**Symptoms and clinical signs.**—As a rule the deformity escapes attention until the child commences to walk, when the parent may notice the shortness of one leg, or the slight limp in unilateral cases, or the hollowness of the lumbar spine or waddling gait in bilateral cases.

Upon examination it is found that there is a limp with a considerable lunge towards the affected side, due to the fact that the unstable false joint slips at each step. In the recumbent position the hip may be adducted, the limb is shortened by ½ to 1 inch or more, and upon measurement of the height of the great trochanter by Bryant's triangle or Nélaton's line it is found that this point is raised to an extent corresponding with the shortening. Traction upon the foot causes the great trochanter to be pulled downwards appreciably, so that the leg becomes longer (telescopic movement).

Movements of the hip-joint in young cases are more free than natural. In older children abduction may be limited.

Upon abducting and flexing the hip-joint it will be found that the attachments of the adductor muscles to the pubis stand out as a strong band with distinct fossæ in front, in the region of Scarpa's triangle, and behind. These fossæ are due to the absence of the head of the femur from its normal position; upon the sound side they are filled up, and this part of the thigh is rounded off. The absence of the head in the acetabulum can be confirmed by pressing the thumb into Scarpa's triangle, when the normally-placed femoral head should be felt immediately beneath the femoral artery. Upon now flexing and adducting the hip the head of the femur can be felt upon the dorsum ilii, and can be readily identified by rotating the limb. If it is not in this situation it must be sought for immediately below the anterior superior spine; if found in this latter situation the dislocation is an anterior one.

In bilateral cases each hip gives these same signs, the shortening of one

limb excepted. In them in the erect position there is much lordosis and a wide interval between the upper parts of the thighs. In anterior dislocations lordosis is absent.

The normal hip-joint in the erect position lies in front of the line of the centre of gravity of the body. The joint is locked and rendered stable by contraction of the gluteal muscles, rendering the anterior part of the capsule tight. In congenital dislocation this normal locking action is impossible because of the mobility of the head of the femur upwards upon the ilium, and in addition the displaced joint now lies behind the centre of gravity of the body. As a result the weight of the body has to be readjusted, and this is done by the production of a lordosis. In anterior dislocations the head of the femur engages against the anterior superior spine, and the displaced joint lies in front of the line of gravity; hence in these dislocations there is no lordosis. An additional valuable sign of dislocation is due to this laxity of the false joint. Normally, in standing upon one leg the hip-joint is braced up by the outer gluteal muscles and by the tensor fasciæ femoris, so that the pelvis is tilted upon the side on which the leg is raised from the ground. In a dislocated hip this bracing up of the joint is impossible, because of the absence of a fulcrum; the pelvis therefore drops upon the side on which the leg is raised (Trendelenburg's sign). This sign is present in dislocations of all sorts.

FIG. 70.—Congenital dislocation of the left hip; tilting of the pelvis when the weight is thrown upon the deformed limb. Trendelenburg's sign.

In early childhood there is little disability from a congenital dislocation. The joint may be easily tired and there may be occasional pain, but except for the limp or waddling gait the child usually runs and plays as if nothing were wrong. Later as she grows and increases in weight the shortening increases, the head of the femur riding further up on to the dorsum ilii, the lordosis becoming consequently more marked. Abduction becomes limited and walking may be very irksome; so that a child who showed very little disability may develop into a woman who is much crippled by her deformity. This tendency for the disability to increase is very important from the point of view of treatment.

*Diagnosis.*—The diagnosis is usually simple. Tuberculous disease of the

hip differs in the presence of pain, limitation of movement, and a definite history of onset. Coxa vara in young children occasionally gives rise to difficulty in diagnosis, the signs being superficially very similar. The most important points in this diagnosis are those dependent upon the discovery that the head of the femur is absent from the proper position in the acetabulum and can be felt upon the dorsum ilii. The absence of the fossæ around the adductors, palpation of the head of the femur in Scarpa's triangle, and the absence of Trendelenburg's sign will generally suffice to distinguish coxa vara. The most difficult cases for diagnosis are those in which a dislocation of the hip is discovered in a child after an acute disease. In them the dislocation may be congenital, or may possibly be due to a dislocation during an arthritis of the hip as the result of distension of the capsule. In such cases there will probably have been some acute signs in the hip during the illness, and in many cases there will have been suppuration. But occasionally the hip

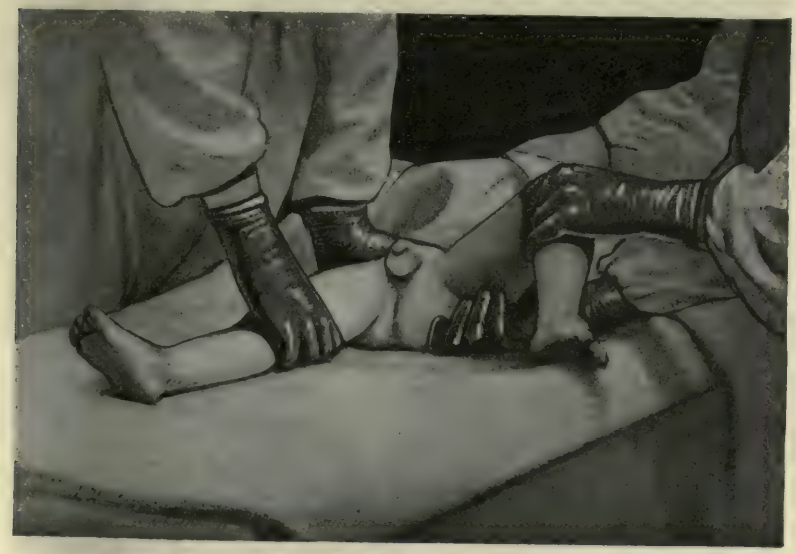


FIG. 71.—Manipulation for the reduction of a congenital dislocation of the left hip.

symptoms escape notice and external suppuration is absent; it will then only be possible to guess whether the dislocation is congenital or pathological by an examination of the skiagraph.

*Skiagraphy.*—A skiagraph will serve as an absolute diagnosis from all conditions except those pathological dislocations just mentioned. In addition to the upward displacement of the femoral head a skiagraph shows other important variations from the normal. The head of the femur is small and less perfectly ossified than it should be; the acetabulum is shallow and its upper lip missing. In pathological dislocations the epiphysis of the head of the femur may be missing, and the upper margin of the acetabulum may be more definitely present than in a congenital deformity. A skiagram of an infant taken before the head of the femur is ossified may be inconclusive; if there is a supposed dislocation in such a case the skiagram should be repeated at the age of one year.

*Treatment.*—All other methods of treatment have practically given way to manipulative reposition of the femoral head in the acetabulum after the

method worked out by Lorenz, so that this method will be described in full. The operation may be carried out in unilateral cases up to the age of eight, in bilateral cases up to the age of seven. As a rule attempts at reduction at a later age are inadvisable, for, although they may be immediately successful, they may be followed by subsequent stiffness, and even by ankylosis of the joint. After the age of seven or eight the lack of development of the acetabulum is likely to prevent the return of the joint to anything like the normal. The best age for operating is one to four years. The child being fully anæsthetised, the assistant holds him firmly down upon the table by the thigh and pelvis of the side that is not to be operated upon. The operator then flexes the affected hip to a right angle and, holding the limb by the knee, gradually abducts it at the hip-joint; his other hand is placed meanwhile beneath the great trochanter and used as a lever to lift this part and lever it forwards.

FIG. 72.—Plaster spica applied in the abducted and inverted position after reduction of congenital dislocation of the left hip.

By slow and steadily-increasing pressure backwards upon the knee and forwards upon the great trochanter the limb is abducted until it lies flat upon the table, the adductor muscles being stretched. In simple cases, at some time during the manipulation the head of the femur is felt to slip forwards into the acetabulum with a click. If it does not slip in readily, further manipulations are tried with the hip more flexed and with such pressure upon the trochanter as will push the head of the femur down towards the lower margin of the acetabulum. If this procedure fails, further manipulations with the limb rotated inwards or outwards are tried until successful. As soon as the head of the femur slips forwards and can be felt beneath the femoral artery the operation is at an end; the limb is then rotated inwards at the hip, so that the leg points backwards, and the pelvis, hip, and knee are fixed in plaster in the position illustrated. This operation is far simpler than that originally devised by Lorenz. In the original method the adductor muscles were first ruptured by beating with the margin of the hand, the

hamstrings were stretched by full flexion of the hip and the structures in front of the joint by hyperextension; manipulations as already described were then carried out to reduce the dislocation. These violent measures are not necessary in ordinary cases. When reduction is not possible at the first attempt, the hip is fixed in plaster in the flexed and abducted position, and a further trial is made in a fortnight's time. The position of after-fixation also differs from that originally introduced by Lorenz in the fact that the limb is inverted. This inverted position is found to make retention of the head in the joint more certain.

The first plaster is retained in position for two months; it is then replaced by a short plaster spica leaving the knee free. In this the patient can walk. The second plaster is retained for two to three months and will probably have to be followed by a third. The total period of retention in plaster will be five to nine months. If after fixation for this time the hip is found to slip out it is probable either that the acetabulum is too small to retain the head of the femur, or that the hip has never really been reduced. Not uncommonly the head of the femur appears to slip into the acetabulum easily, but really only does so with a fold of the capsule which it carries before it. If this has occurred the dislocation will recur.

*Prognosis.*—Manipulative reduction in young children gives a good prospect of anatomical cure. The proportion of complete cures is variously stated from 30 to 90 per cent.; cases in which there is not complete reduction are nearly always converted into anterior dislocations by the operation and thereby much improved.

Accidents as the result of operation done at the proper age and by careful methods are practically unknown at the present day. Among the earlier cases fracture of the femur, rupture of the femoral vessels, injury to the sciatic nerve, and gangrene of the leg all occurred, owing to misplaced violence.

*Treatment of relapsed and neglected cases.*—Relapse into an anterior or posterior dislocation may occur after successful reduction as a result of a defect in the upper margin of the acetabulum. A second reposition is always justifiable, but if the treatment has been carried out with due care in the first place it is not likely to be successful. In such relapsed cases an open operation may be done to sew up the posterior part of the capsule and raise the periosteum over the upper margin of the acetabulum in the hope that additional bone may be formed there. At the same time it will be possible to ascertain whether the hip has really been properly reduced or whether it has carried a fold of capsule into the acetabulum; if the latter has occurred it is necessary to open the joint and to see that the head of the femur really enters the joint. Open operations for the replacement of dislocations of long standing have been performed in the past and have occasionally been successful; but they are not considered advisable at the present day, as they usually fail to improve and may make the disability worse.

In older untreated cases much of the disability is due to fixed adduction; a good deal of improvement may be obtained by tenotomy of the adductors, forcible abduction of the hip, and fixation in plaster in the abducted position for a period of a year or more.

The only other congenital deformity of the hip of any importance is congenital coxa vara; this is described with the other varieties of coxa vara.

**Congenital deformities of the knee.**—These are rare; the most frequent is a variation in the shape of the articular surfaces, which causes stiffness of the joint, even to the extent of complete immobility. This most often occurs in conjunction with other deformities—for example, with club-foot. Repeated

manipulations will restore much of the proper movement. A second occasional deformity is genu recurvatum or hyperextension of the knee, sometimes termed " congenital dislocation of the knee." This must be treated by splinting and later by a walking apparatus to prevent hyperextension. A third congenital defect in this region is the absence of the patella. This may coexist with the two last-named defects or may occur alone. It may occur in several members of one family; and the patella may be absent, rudimentary, or merely late in development. There may be undue mobility of the knee in the direction of hyperextension, or there may be no disability whatever.

**Congenital defects of the leg and ankle.**—The most important of these are defects of the tibia and fibula. Absence of the tibia is very rare. When it occurs the fibula is enlarged and articulates directly with the femur; the foot is twisted into an extreme varus deformity, so that it may lie flat against the inner side of the leg. In such cases attempts have been made to straighten the foot in infancy, and later to graft bone to replace the tibia, or to split the fibula into two halves. As a rule a more useful limb will be obtained by amputation and the provision of an artificial limb.

Congenital defect of the fibula generally coexists with bending of the lower part of the tibia and with reduction in number of the toes; the composite deformity so produced is sometimes called " congenital fracture of the tibia." The whole fibula or its lower end may be missing; the tibia is short, and its lower end presents an angle pointing forward, over which there is a dimple in the skin; the foot is in an extreme position of valgus, with some contraction of the tendo Achillis, and the toes are reduced to four or three by the disappearance of those on the fibular side. In rare cases the tibia presents an ununited fracture at the site of the angle. The deformity may be unilateral or bilateral. Nothing is known of its cause. In slight cases attempts at correction by osteotomy of the tibia, tenotomy, and forcible manipulations may be tried. In more severe cases the permanent use of supporting apparatus is the only mode of treatment. In the worst cases amputation and the provision of an artificial limb will give a more serviceable leg. Osteotomy of the tibia in these cases is not by any means a safe operation—the bone sometimes fails to unite; in these cases and in those in which the tibia is ununited at birth, attempts made by wiring, plating, or even by bone-grafting usually fail to secure union, and the patient must wear a permanent supporting apparatus or else submit to an amputation.

**Deformities resulting from rickets and allied adolescent deformities.**—**Coxa vara.**—Coxa vara is the name given to that anatomical condition in which the angle made by the neck and shaft of the femur, normally about 125 degrees, is diminished. Briefly summed up, the clinical manifestations of coxa vara are a diminution in the amount of abduction permitted at the hip-joint and real shortening of the limb, manifested by raising of the level of the great trochanter. In several conditions other than coxa vara these clinical signs are present, but the deformity is in the head rather than in the neck of the femur. These, although often termed coxa vara, are best kept in a different category; they are:—

1. Old inflammatory disease of hip-joint, either tuberculous or septic;
2. Osteoarthritis; and
3. The chronic non-tuberculous inflammation of the hip-joint described by Calvé as " pseudo-coxalgie."

True anatomical coxa vara may be due to a number of different pathological causes, and may further vary in its pathological anatomy. In some cases the alteration in angle is at the point of junction of the head of the

femur with the neck (*epiphyseal coxa vara*); in some it is constituted by an angle in the neck or at the junction of the latter with the shaft (*cervical coxa vara*); in some there is a general curvature of the whole neck. Fracture of the neck of the femur with union in a deformed position or with fibrous union is an evident cause of coxa vara, as are also those diseases in which the bone is softened and gives way under the pressure of the weight of the trunk—for example, rickets, osteomalacia, osteitis deformans, and fibro-cystic disease. But apart from these coxa vara is found as a congenital deformity, and arises apparently spontaneously during childhood (*infantile* or *cervical coxa vara*), or during adolescence (*adolescent* or *epiphyseal coxa vara*); the description here will be confined to these idiopathic forms, and to the form of coxa vara which results from rickets.

FIG. 73.—Adolescent coxa vara showing adduction deformity and prominence of the great trochanter.

**Adolescent or epiphyseal coxa vara.**—The adolescent is the most frequent of the varieties; it occurs much more commonly in boys than in girls, and is usually unilateral, only rarely bilateral.

*Symptoms and physical signs.*—The onset of coxa vara is insidious. There is some pain, often not severe, and frequently referred to the knee; with this there may be a slight limp. Sometimes the shortening of the limb is first noticed by the patient, and advice is sought for this.

Upon examination in a case of recent onset the limb is found adducted and everted at the hip-joint, and all movements at this joint are much limited or even completely abolished. This limitation of movement is temporary—it may last a few weeks only or many months; but eventually it disappears, but certain movements remain limited by anatomical factors. The early fixity of the joint is due to muscular spasm, and must be ascribed to the fact that the site of the lesion is the epiphyseal line of the head of the femur, which is situated within the capsule of the joint, so that the progressive stages of the deformity are accompanied by a synovitis. In the later stages abduction and internal rotation at the hip are limited; this limitation is permanent. Wasting of the thigh occurs early, and some real shortening of the limb will be found upon careful measurement in every case. Measuring by means of Bryant's triangle or Nélaton's line, this shortening will prove to be above the great trochanter, that is to say, in the neck of the femur.

The diagnosis from tuberculous disease—the only condition likely to be

confused with adolescent coxa vara—can usually be made by the history and physical signs, the presence of adduction and eversion, with real shortening at an early stage of the disease without any very acute symptoms, being characteristic. A skiagraph will render the diagnosis certain. In it the

Fig. 74.—Adolescent coxa vara which followed several slight accidents. (The line of separation of the head of the femur from the neck has been exaggerated in retouching the photograph.)

deformity is seen to consist in a downward and backward displacement of the head of the femur at or close to the epiphyseal line.

In one important point cases of adolescent coxa vara differ from each other. As already stated, the onset is insidious, and the deformity is usually well established before advice is sought. But in some cases the deformity arises suddenly immediately after an injury to the hip. In these there has been a separation of the epiphysis of the head of the femur. This accident may be produced by slight violence, usually by torsion of the limb, and it may

cause comparatively little disability at the time, the patient being able to get up and walk after the accident. These cases of complete separation of the epiphysis are rare. Much more commonly upon questioning the patient it will be found that he injured the hip some months before and thought nothing of the accident at the time, but that subsequently he began to suffer from pain in the knee, and that then the deformity arose. In these cases there has been a loosening of the epiphysis at the time of the accident, and this has resulted in subsequent gradual slipping of the epiphysis downward and backward upon the neck. This class includes the majority of cases of adolescent coxa vara, which must therefore be considered as in the main a traumatic deformity; but in certain cases there is no injury recorded, and in these the deformity may be bilateral, the latter point being strong evidence against a traumatic theory of origin. In such cases the skiagraph shows that the anatomical lesion is essentially similar to that in the non-traumatic cases, there being a displacement of the epiphysis. One other point requires mention—the separation of the epiphysis has occurred after the deformity is established, and there is no doubt that the presence of a coxa vara deformity renders this epiphysis more vulnerable.

In those cases which are not due to an injury it is necessary to suppose that there must be some pathological reason for the slipping downwards of the head of the femur, and in traumatic cases there may be some reason for the readiness with which the injury occurs. Such a reason can be found by supposing that the epiphyseal line of the femoral head is in these cases the seat of a defective process of ossification such as has already been described in the sections upon *Rickets* and *Late Rickets*.

*Treatment.*—A careful examination of all injuries of the hip, particularly of those occurring during childhood and adolescence, by skiagraphs, with the treatment of all injuries of the femoral neck in the abducted position, should prevent the occurrence of a certain number of cases of adolescent coxa vara.

During the progress of the deformity the essential points in the treatment are first to secure that full abduction of the hip is possible and then to relieve the neck of the femur from weight-bearing until time has been given for the bone to consolidate. Full abduction may be secured either by fixing Thomas's splints to both lower limbs and extending this with a heavy weight extension in a widely abducted position on a four-post frame, as in the treatment of a high fracture of the femur; or a rack splint may be applied to the hip, incorporated in plaster of Paris which encloses the pelvis and the thigh, and the hip gradually racked into a fully-abducted position. Forcible abduction under an anæsthetic may secure full abduction by completely separating the head of the femur and replacing it in its proper position upon the neck; but such a manipulation is unsafe, for the head of the femur may become absorbed and bony ankylosis of the joint result. When full abduction has been secured the hip can be relieved of weight-bearing by the use of a Thomas caliper splint (see p. 265), which carries the weight direct from the pelvis to the ground. This splint should be worn for a long time—certainly for many months—in order that the neck of the femur may have time to readjust its architecture to the altered pressure conditions set up by the displacement of the femoral head.

Adolescent coxa vara treated by such conservative methods leaves very little disability. There may be some half-inch of shortening and perhaps a little limitation of movement, and in some cases the eversion may be unsightly. At this stage, if more abduction is required or if it is desired to

correct the eversion, osteotomy through the trochanters may be performed. Except at this period operation is not required in adolescent coxa vara.

**Infantile or cervical coxa vara.**—This form of coxa vara is somewhat less common than the adolescent variety; it is equally common in boys and girls, and is frequently bilateral.

*Symptoms and physical signs.*—In these cases there is no acute onset; the child limps or in bilateral cases walks with a waddle, but it is impossible to fix accurately the time of onset of this symptom. Sometimes a peculiarity in the gait is noticed as soon as the child walks; more often it becomes evident at a later age, up to the eighth or tenth year.

FIG. 75.—Infantile or cervical coxa vara.

The physical signs are very different from those of the adolescent deformity. The hip is permanently flexed and adducted; movements are free except full extension and abduction, whilst rotation in either direction may be less than normal. There is no stage of complete loss of movement as in the adolescent cases. The limb is shortened and the trochanter proportionately raised. This position of the hip causes much lordosis—the trochanters are very prominent, the distance between the thighs is wide. There is a close superficial resemblance to congenital dislocation of the hip, with which this variety of coxa vara is liable to be confused (see *Congenital Dislocation*). The disability tends to increase with growth, the weight of the trunk increasing the deformity of the femoral neck. In severe unilateral cases the apparent shortening from adduction may be very great and in bilateral cases the legs may actually cross when the child walks. Little is known of the causation. In a few cases there is a definite history of an injury; many of the children are said to have suffered from rickets, but evident stigmata of rickets are usually absent.

Skiagraphs show a depression of the femoral neck occurring at the junction with the shaft of the bone, the angle made being in most cases actually an acute one; the neck often shows a clear intersection extending into it from the upper margin, indicating that the bony neck is interrupted here by an intersection of fibrous tissue. Such a fibrous intersection has been found in the few specimens which have been examined. In order that the pathological anatomy of this class of coxa vara may be understood it must be remembered that at birth the whole of the upper end of the femur, including the head and the great trochanter, consists of a continuous mass of cartilage; in this the epiphysis of the head appears during the first year and that for the great trochanter in the fourth year. During these first four years the neck of the bone is largely cartilaginous, the lower part only being ossified. It is only

when the child is four years old that by an extension of ossification the upper part of the neck becomes bony; up to this time there is a bridge of cartilage connecting the head of the femur with the great trochanter. In this type of coxa vara deformity there can be no doubt that a solution of continuity has occurred in the neck of the femur during these first years,

FIG. 76.—Infantile or cervical coxa vara in a patient aged 14, showing the acute angle between the neck and shaft of the bone, and the intersection of fibrous tissue.

when this part of the bone is largely cartilaginous, and that, as might be expected in an injury through cartilage, fibrous union only occurs. In a few cases the history of an accident can be clearly obtained; in the majority, however, this history is missing.

*Treatment.*—This deformity is of considerable rarity, and its recognition is in addition so recent that it is impossible to be dogmatic about its treat-

ment. The use of a caliper walking instrument, by relieving the hip from weight-bearing, will prevent the progress of the deformity, but as the condition arises early in life this line of treatment may necessitate the use of such a splint for many years. In cases of moderate severity an osteotomy carried out through the great trochanter, and combined with tenotomy of the adductors, will restore full abduction at the hip, and by altering the line of weight through the neck it will also arrest the progress of the deformity. This is the appropriate treatment when the angle of the femoral neck is a right angle or less. In very severe cases and in older children good results have been obtained by the removal of the head of the femur through the fibrous line, a plaster spica being worn afterwards until the joint is stable. This treatment leaves much shortening, but the movements are free and the gait much improved.

**Congenital coxa vara.**—It is possible that some of the cases classed as infantile coxa vara are really congenital. But the only cases usually included as congenital are those in which there is some associated deformity, such as shortening of the femur or talipes. In such cases, which are very rare, the deformity resembles the infantile variety in its clinical characters; in skiagraphs the angle is found to be at the junction of the femoral neck with the shaft, but there is no fibrous intersection in the neck.

**Rickety coxa vara.**—Ordinary infantile rickets rarely produces any deformity of the neck of the femur, probably because at the age at which the disease is active this part of the bone is cartilaginous. Occasionally in cases of severe rickets there is lordosis, with limitation of abduction at the hip-joint and raising of the great trochanter. In these cases, which are properly called *rickety coxa vara*, skiagraphs show that there is a curve in the bone extending throughout the neck and upper part of the shaft, so that there is a general depression of the femoral neck, which does not resemble either of the two varieties of coxa vara already described. Rickety coxa vara does not require treatment.

**Genu valgum.**—Genu valgum, or knock-knee, is that deformity in which the femur and the tibia form an abnormal angle at the knee, the angle opening outwards.

It is one of the commonest deformities both in childhood and in adolescence. It is more frequent in boys than in girls, and may be unilateral, but is more often bilateral.

Knock-knee may arise soon after the child learns to stand and walk, or at any time during growth, as a minor deformity. It is found throughout childhood; but as a major deformity it occurs chiefly at the age of two to five, when it is due to rickets, or at the age of twelve to fifteen, when it is an adolescent deformity. The pathology and mechanical production of these deformities have been already described.

Anatomically, genu valgum may be due to curvature of the shafts of the femur and tibia, to abnormal obliquity of the articular extremities of these bones in relation to the direction of the shafts, or to abnormal size of the internal condyle of the femur. Curvature of the bones is commonly found in the rickety variety of the deformity, obliquity of the femoral condyles in the adolescent variety. All knock-knee except that due to bending of the tibia disappears upon flexing the knee.

Knock-knee may arise from other causes, of which the most frequent are contraction of the biceps muscle in a paralysed leg and contraction of the biceps and destruction of the ligaments or articular surfaces in tuberculous disease of the knee. In these the deformity is at the joint and not in the

bones, and is accompanied by flexion of the knee and posterior displacement of the tibia.

In severe cases of rickety knock-knee considerable secondary deformities arise in the tibia. The articular surfaces of the upper end become unequal, the internal being large, the external small; the tibia is rotated out upon the femur, its tubercle and crest become flattened, an exostosis arises on the internal tuberosity, and the internal border becomes so prominent as to simulate a new crest. In such cases the biceps tendon is often much shortened. In rickety knock-knee the feet may be flat. In older subjects the feet are often strongly adducted and inverted in order to bring them more nearly beneath the centre of the body; in such cases the feet become over-arched.

*Prognosis.*—A slight degree of knock-knee is extremely common in childhood. Normally, when the malleoli are in contact the fully-extended knees should show a very narrow interval. In a very large proportion of children this interval disappears, and with the knees in contact it is impossible to get the malleoli to touch, unless the knees are flexed. Such slight knock-knee may be safely left to correct itself with further growth. A more severe deformity, however, particularly if it arises rapidly in early childhood or at twelve to fourteen, does not so tend to correct itself and will probably be permanent. Persistent knock-knee alters the strain upon the knee-joint, throwing undue weight upon the internal condyle and internal lateral ligament. It may render the joint more liable to the degenerative changes of osteoarthritis.

*Treatment.*—Expectant treatment is indicated in the slight cases just mentioned. It may be supplemented by increasing the thickness of the inner side of the sole of the boot, so as to throw more weight on to the outer side of the knee, and by exercises in which the knee is forced outwards during flexion. Such exercises are :—

1. Tip-toe, full knee-bend and stretch.
2. Feet astride, tip-toe, alternate knee-bending.
3. Rowing exercise.

Rather more severe cases, particularly when there is or has recently been active rickets, may be treated by mechanical supports. The simplest form of support consists of a wooden splint fitted into a slot in the outer side of the shoe and extending up to the level of the great trochanter. This is kept away from the external malleolus and from the trochanter by pads and the knee drawn over to it by a bandage or by straps. It is essential to keep the knee extended, and in order to do this in the more efficient apparatus (the Thomas knock-knee brace) the wooden splint is replaced by a steel bar and supplemented by a second bar placed behind the knee and extending from the middle of the thigh to the middle of the calf.

In more severe cases the deformity must be corrected by operation, but it is not advisable to operate before the age of four years unless the deformity is extreme. Several modes of operating have been devised, but practically only one is used at the present day, viz., osteotomy of the femur at a short distance above the level of the adductor tubercle (McEwen's osteotomy). The operation is performed subcutaneously with an osteotome through a small vertical incision immediately above and in front of the adductor tubercle. The knee should be kept flexed, and the lower end of the femur should lie upon a sand-bag during the operation. The posterior part of the bone is cut through first, then the anterior; the outer side may be broken. Some surgeons prefer to divide the bone from the outer side. Immediately after the bone is divided it is brought into a slightly over-corrected position and the limb enclosed in plaster from the foot to the level of the hip-joint.

Some prefer to fix the limb upon a Liston's splint for ten days, but this necessitates a second anæsthetic for the application of the plaster. This operation is remarkably safe and satisfactory; the only accident likely to occur is section of the anastomotic artery, necessitating enlargement of the incision and ligature. The femoral vessels have been wounded both by the osteotome and by splinters from the posterior part of the bone. The plaster is retained for six weeks in small children or eight weeks in adolescents. The patient is then allowed to walk upon the limb. Mechanical support is only required after operation in cases in which the knee-joint is lax or in which the deformity has been imperfectly corrected. In severe cases it may be necessary to divide the tendon of the biceps before the deformity can be corrected, and in cases in which there is much tibial deformity it may be advisable to divide the shaft of this bone as well as the femur.

Other operations for knock-knee are now only of historical interest; but on the Continent forcible correction of the deformity under an anæsthetic is sometimes carried out. The result is either to stretch or rupture the ligaments on the outer side of the joint or to separate the lower epiphysis of the femur. It is not advisable to correct the deformity in either of these ways.

**Genu varum and bowed tibia.**—These deformities are essentially the result of rickets, and their pathology and mode of production have been already described. Bowing of the knees and legs never occurs for the first time during adolescence, although a rickety bowing may increase at that time.

Anterior bowing of the tibia due to old rickets is occasionally confused with that due to congenital syphilis. Rickety bowing arises in the first place in the lower part of the tibia; it may, however, affect the greater part of the length of the bone, and a bowing which first occupies the lower half of the shaft may move up as growth occurs below it until the chief curve is at the centre of the shaft. Rickety curves are not accompanied by pain, inflammatory signs, or thickening of the anterior surface of the bone; there is, however, a buttressing of the posterior part of the bone, to be felt, or seen in skiagraphs. Syphilitic periostitis of the tibia (*tibia en lame de sabre*) gives rise to a general curvature forwards of the whole bone, most marked near the upper end. The surface is rough, thickened and often hot, painful and tender to pressure. There is no buttressing of the posterior part of the bone.

*Treatment.*—Expectant treatment should be carried out in all cases up to the age of four years. If the deformity at that age is slight or is improving rapidly, it may be left alone. If it is still considerable, operative interference should be carried out forthwith. The use of splints for this condition has been already discussed.

When operative treatment is undertaken it is first necessary to estimate the site and character of the deformity. Cases may be divided into those showing an inward concavity of both tibia and femur, those showing an anterior concavity of the tibia, and those showing composite deformities, such as inward concavity of the tibia with knock-knees.

For inward concavity of the tibia osteoclasis is the operation of selection; it is preferably carried out at the age of four to five years, for at that period it can be carried out by the hand alone. The child is anæsthetised, turned on to the side, and the convex side of the leg placed across a wedge at the side of maximum curvature. The tibia is then grasped firmly, with the operator's hands above and below the wedge, and gradually-increasing pressure made until the bone is heard to break with a sharp crack. The limb is then found to be straight; it is fixed immediately in plaster extending from the toes to immediately below the knee, which is retained for one month. Skiagraphs

show that a greenstick fracture is produced, the fibula being sometimes fractured, sometimes uninjured. After the age of five years the bones will usually be too hard to enable fracture with the hand to be carried out. Osteoclasis can still be carried out by means of an osteoclast, but as the amount of bruising thus caused is considerable, and as the fracture will probably be complete, an open operation is preferable upon these older cases. Osteotomy is best performed from the inner (concave) side, the bone being partly cut through and then broken over the wedge. After the wound has been sutured the limb is fixed in plaster as after osteoclasis. Anterior convexity of the tibia is more difficult to correct; it necessitates an osteotomy, often with the removal of an anterior wedge. This osteotomy should not be performed at too low a level in the tibia, as occasionally a very low osteotomy of the tibia fails to unite.

Deformity of the femur should be left and corrected after the tibia has been straightened, for only then can its extent be accurately estimated. Genu varum is corrected by an osteotomy carried out in exactly the same way as is that for genu valgum.

**Defective growth of the bones of the lower limb.—The upper epiphysis of the femur** is not an important one except in so far as it is concerned in the development of the neck of the femur. The part played by injury to this epiphysis in the production of coxa vara has already been described.

**The epiphyses of the femur and tibia at the knee** are the most important growing epiphyses of the lower limb. Their growth is comparatively seldom affected by injury or by acute inflammation, although occasionally growth may be lessened by these causes; or it may become irregular, genu valgum or genu varum resulting. By far the most common cause of injury to these epiphyses is the operation of excision of the knee—shortening of the limb as the result of diminished growth, genu varum, genu valgum, genu recurvatum (hyperextension), or flexion of the knee being all frequent as the result of excision of the joint carried out in early life.

**The lower epiphysis of the tibia** is an important one, nearly half the growth in length of the tibia taking place at this site. Diminution of growth is not very uncommon as the result of injury or inflammation. When it occurs growth is almost always irregular, the outer side of the bone growing more rapidly than the inner. The lower end of the tibia then bends and becomes concave inwards, the foot becomes deformed, the position of talipes varus being assumed, and the fibula extends downwards over the outer side of the foot.

**The fibula** may have its growth arrested without any serious disability resulting, either as a congenital defect or in association with multiple exostoses, or as the result of injury or inflammation. If the upper end is affected, the head of the bone may become disarticulated from the tibia and be found in the middle of the leg. If the lower end is affected, a similar disarticulation is found; in this case the disappearance of the external malleolus may result in a bad valgus deformity of the foot.

**Painful enlargement of epiphyses.—Enlargement of the tubercle of the tibia** was first described by Osgood and by Schlatter in 1903. It often goes by the name of *Schlatter's disease*. It arises in adolescents aged twelve to eighteen years, sometimes as the result of a definite injury, usually whilst jumping or running, sometimes as the result of less definite repeated injuries, sometimes as the result of chronic irritation, for example from kneeling. In some cases the trouble is unilateral, in others it is bilateral. The tubercle is obviously enlarged, showing up specially when the knee is flexed. It is tender on pressure, and sometimes also pains when the quadriceps is actively used.

The pain may last for months or years; the enlargement is permanent. Osgood, Schlatter and others have described the condition as due to a partial separation of the epiphysis by traction through the patellar ligament, but this, although it is the cause in some cases, will not account for those in which kneeling has given rise to the condition. Probably there is an inflammatory enlargement of the epiphysis, with irregularity in its ossification, resulting either from trauma or from chronic irritation. X-ray photographs show varying changes. In some the epiphysis of the tubercle is an entirely separate nodule, in others it consists of a prolongation downwards from the epiphysis of the head, and in the latter this prolongation may be separated from the main shaft of the tibia by an unusually wide interval as if it had been pulled away from it. In all cases the anterior surface of the epiphysis is uneven and there are often small separate ossifications in the patellar tendon. Probably the irregularity of the epiphysis and these small ossifications are the real changes of the inflammatory condition present, and the variations seen in different cases are due to differences in the mode of ossification of the tubercle, or to different stages in this ossification.

FIG. 77.—Enlargement of the tubercle of the tibia.

The only treatment that is of any avail is to rest the knee on a back splint when it is painful. In most cases there is no ultimate disability, but, occasionally, spicules of bone which develop in the tendon remain tender in adult life.

**Enlargement of the heel.**—A similar painful enlargement of the epiphysis of the os calcis which forms the point of the heel occasionally arises in adolescents. It is a similar inflammatory condition due to irritation. It should be treated by protection from injury and friction, and by rest when it is painful.

**Kohler's disease.**—In young children, aged about three to five, a painful enlargement of the scaphoid bone of the foot sometimes occurs without any apparent cause. X-ray photographs show that the nucleus of the bone is small and irregular and sometimes divided up into sections. This condition is probably an inflammatory or possibly vascular lesion of the bony nucleus of this bone. Although this is not an epiphysis the condition appears to be similar to that in enlargement of the tubercle of the tibia. Treatment in the painful stages is by rest. *Pseudocoxalgie* is a similar condition in the epiphysis of the head of the femur, possibly due to an interference with the blood supply, and a painful condition of the epiphysis of the great trochanter has also been described.

**Paralytic deformities of the lower limb.**—A general account of paralytic deformities will be found in the section upon deformities in general. Two

special points in connection with the treatment of paralytic deformities of the lower limb require further mention—the principles of the use of walking instruments in flaccid paralyses of the type of infantile paralysis, and the special operations performed in the later stages of such paralysis. The nomenclature, mode of production, and principles of treatment of paralytic deformities of the foot will be found under *Talipes*.

**Walking instruments.**—In its most general form a walking instrument for the lower limb includes a boot with steels extending from a socket in the heel up the inner and outer sides of the limb to the upper part of the thigh, and continued up the outer side to a steel band around the pelvis; joints are fitted opposite each natural joint, and as far as possible imitate the movements of the joints. To such steels straps can be fitted to pull the foot towards the outer steel (valgus strap) or towards the inner steel (varus strap), these straps being named according to the deformity which they correct. A knee-cap can be fitted to pull the knee backwards or inwards or outwards; springs or accumulators can be arranged to assist in any particular movement of a joint, as, for example, to elevate or depress the toes; stops can be inserted to limit the movement of a joint in any particular direction, or a joint, such as the knee, can be fixed by a pin through the steels or by a lock, so that the patient walks with a stiff knee. It is of course unnecessary to fit a complete instrument in every case; in some a single steel up one side of the limb will suffice, and in many it is only necessary to carry the instrument up to the top of the calf. If a valgus deformity of the foot has to be corrected, an outside steel is essential; if a varus deformity is present, the steel must be fitted upon the inner side.

The object of such an instrument is to enable the patient to walk with as nearly as possible the natural action, and it is for this reason that in the usual types of instrument the natural joints are imitated. The continuation of the steel to the pelvis may be necessary in order to support the hip-joint; more often this continuation is added in order to invert or evert the limb, there being no point below the pelvis from which this can be effected. The ideal of a walking instrument should not be to replace permanently the natural use of the limb, but rather by keeping the limb in natural use to enable it eventually to recover its normal function. If we remember that paralysed muscles which retain some power will in most cases recover if they are supported, it will be realised that the use of complete walking instruments with full joints is often unnecessary. It may be sufficient to apply some apparatus which will keep the knee extended, the foot at a right angle and supported laterally, and will if necessary give some support to the hip-joint. In the early stages of the paralysis and in young children celluloid splints are very efficient for this purpose, but for older children some stronger support is desirable. For such the caliper walking instrument is the best. This consists of a ring around the thigh on the pattern of that of a Thomas's knee-splint and steel bars extending down the inner and outer sides of the limb to be fitted into a socket in the boot; the knee can be held into this instrument by knee-caps pulling in any direction, and the foot may be drawn by a strap to either the inner or the outer bar. If the patient walks upon his toes (*talipes equinus*), this can be corrected by placing the socket in the boot in front of the ankle-joint; if he walks upon his heel (*talipes calcaneus*), the socket should be fitted far back. Such an instrument is simple and cheap; it gives support to the hip, as the weight can be carried direct from the pelvis to the ground through the ring and side steels, and it keeps the knee and foot in good positions. With a caliper splint a patient can walk upon a limb which possesses

no power in any muscles, although walking will not be good unless there is some remnant of action in the glutei.

**Operations for paralytic deformities of the lower limb.**—Excluding tenotomy, tendon lengthening, and correction of deformities by means of the wrench, the operations for paralytic deformities fall into two main groups—those for altering the action of muscles by transplanting their tendons, and those for the fixation of flail joints. The general principles for the application of these procedures have been already indicated, but a few further details must be added.

For the successful transplantation of a tendon it is necessary that the line of action of the muscle should not be altered to such an extent as to place it at an impossible mechanical disadvantage; it should never be made to work around an angle. In the second place the new attachment must be secure; for this reason it is generally considered better to fix the tendon into the periosteum of a bone rather than into the distal extremity of a paralysed muscle. And in the third place it is useless to transplant a tendon unless any existing deformity has first been corrected, so as to enable the tendon to be fixed in its new position with a full correction of the deformity and with a certain amount of tension upon the tendon.

As useful examples of tendon grafting the following may be given:—

Transplantation of the whole of the tibialis anticus into the cuboid for paralysis of the peronei.

Transplantation of the extensor proprius hallucis into the internal cuneiform or of the peroneus longus into the inner side of the scaphoid across the back of the tibia for paralysis of the tibial muscles.

Transplantation of the long flexor tendons and of the peroneus longus into the tendo Achillis for paralysis of the gastrocnemius and soleus.

Other transplantations sometimes performed, but which are unlikely for mechanical reasons to be successful, are:—

Transplantation of the peroneus longus or brevis across the front of the ankle-joint to the inner side of the foot. This requires these tendons to work around an angle.

Transplantation of the tendons of the hamstrings into the patella, again requiring an impossible line of action of the muscles.

This list is in no way exhaustive; the transplantations named are only given as examples of good and bad methods.

By *arthrodesis* is meant an operation for the fixation of a joint. The cartilage is removed from the joint surfaces until cancellous bone is exposed, the surfaces are shaped until they lie in accurate apposition, and the joint is then fixed in plaster or upon a splint until time has been given for bony union to take place. In the lower limb arthrodesis is usually reserved for the ankle and tarsal joints. Fixation of the hip is exceedingly difficult. The knee can be held securely and easily by an instrument, and a permanently-fixed knee may be a considerable inconvenience. But in many cases of paralysis with complete loss of the leg muscles it is very difficult to retain the foot in a good position. In these synostosis of the ankle, subastragaloid, and mid-tarsal joints may greatly improve the function. It is, however, necessary to fix all these joints; an arthrodesis of the ankle-joint only is seldom of much use. Such an arthrodesis of the tarsal joints is a difficult operation on account of the difficulty of access.

Whitman's operation has been devised to replace arthrodesis, more particularly in cases of paralytic talipes calcaneo-cavo-valgus. It consists in the removal of the astragalus and the displacement of the foot backwards so

that the internal malleolus rests upon the inner side of the scaphoid and the outer malleolus upon the calcaneo-cuboid joint; a stable foot is thus produced, a little movement being allowed at the new joint formed and the weight being borne directly upon the summit of the arch of the foot. The operation is a useful one, and very much simpler than arthrodesis.

**Deformities of the foot.—Anatomical considerations.**—The bones of the foot are arranged for weight-bearing; they form arches in the longitudinal and transverse directions which are important in relation to this function. Longitudinally, the chief arch is formed upon the inner side of the foot by the os calcis, astragalus, scaphoid, internal cuneiform and first metatarsal bones, the bearing points being the tuberosity of the os calcis and the head of the first metatarsal, and the summit of the arch being at the astragalo-scaphoid joint. Upon the outer side the longitudinal arch is formed by the os calcis, cuboid, and fifth metatarsal bones; this external arch is filled in below by soft parts, so that although there is a bony arch the skin is in contact with the ground. Transversely, an arch is formed by the cuneiforms and metatarsal bones, the most important part being the arch formed by the heads of the latter bones; here again the arch is filled in by soft parts. It thus comes about that the bearing points upon which the foot rests are the tuberosity of the os calcis and the heads of the first and fifth metatarsal bones.

These arches are kept up partly by ligaments—the calcaneo-scaphoid, long and short plantar, and transverse metatarsal ligaments, and the plantar fascia being the most important—and partly by the action of muscles. The most important muscles concerned are:—

The tibialis anticus, attached to the internal cuneiform and base of the first metatarsal, which lifts the internal arch directly upward.

The tibialis posticus, wrapped round the summit of this longitudinal arch, and attached to all the tarsal bones except the astragalus.

The long flexor muscles, which pull the anterior pillars of the longitudinal arch backwards.

The muscles of the sole in general, which assist in approximating the pillars of the longitudinal arches.

In addition to these, which have an evident direct action in maintaining the arches, the gastrocnemius and soleus and the peronei are important. The former, although they have no direct action upon the arches of the foot, have indirectly an important effect. If the tendo Achillis is unduly short so that the heel just fails to reach the ground, a severe strain is placed upon the longitudinal arch, for by everting the foot at the sub-astragaloid joint the distance to the attachment of this muscle is shortened, and by further everting the fore part of the foot at the mid-tarsal joint the fore part of the foot may be made to lie flat upon the ground. Such eversion, however, greatly strains the astragalo-scaphoid and plantar ligaments, and may lead to a severe degree of flat-foot.

The peroneus longus, passing transversely beneath the foot, assists in maintaining the transverse arch; in addition both the peronei abduct the fore part of the foot, and thus depress the longitudinal arch. So that we find that paresis of these muscles is an important cause of overarching of the foot.

The movements which occur at the ankle and tarsal joints are complicated, and unfortunately the chief movements at the ankle-joint have been wrongly named by anatomists. In the following account depression of the foot carried out by the gastrocnemius, soleus, long flexors, tibialis posticus, and peronei will be termed *plantar flexion;* the opposite movement, carried out by the long extensors and tibialis anticus, being termed *dorsal extension.* These

movements take place chiefly at the ankle-joint, which probably allows no other movement, although according to some anatomists in the mid-position of the joint a certain amount of lateral movement is allowed.

The other movements of the foot may be reduced to two, each of which is, however, somewhat complicated. In the first (*varus*) the foot is adducted and inverted, the sole faces inwards, and the arch is increased. This movement is usually combined with plantar flexion at the ankle; it is carried out by the tibialis anticus, tibialis posticus, and long flexor muscles. In the

FIG. 78.—Varus movement of the foot. Adduction and inversion.

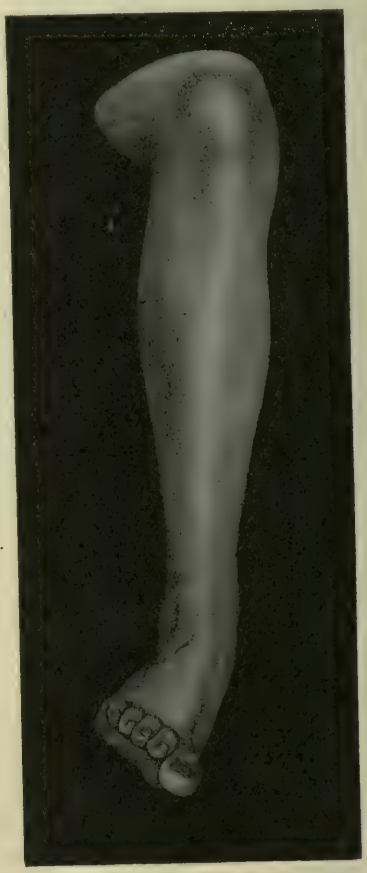


FIG. 79.—Valgus movement of the foot. Abduction and eversion.

opposite movement (*valgus*) the foot is abducted and everted, the sole faces downwards and slightly outwards, and the longitudinal arch is depressed. This movement is usually combined with dorsal extension at the ankle-joint, and is carried out by the peroneal muscles and long extensors. These movements take place chiefly at the subastragaloid and mid-tarsal joints; at the latter joint a small amount of plantar flexion of the fore part of the foot is also possible.

**Nomenclature of deformities of the foot.**—Deformities of the foot may be postural or fixed. With one exception they consist of positions which can be assumed by the normal foot or of exaggerations or combinations of

these; they may be derived, therefore, from the movements of the foot already named. The exception is the condition of flat-foot, in which the longitudinal arch is abolished, for this arch cannot be abolished in the normal foot as long as the ligaments are intact.

**Talipes equinus** is that condition in which the foot is held in the position of plantar flexion, whether the deformity occurs at the ankle-joint or at the mid-tarsal joint. It is so named because in the horse the heel is raised in the air, the weight resting upon the heads of the metatarsal bones.

**Talipes calcaneus** is the opposite condition, in which the foot is held in the dorsally-extended position, the weight resting entirely upon the calcaneum.

**Talipes varus** indicates that the foot is held in the position of inversion and adduction.

**Talipes valgus** indicates that the foot is held in the position of eversion and abduction.

**Pes cavus** is that condition in which the longitudinal arch is increased.

**Pes planus, or flat-foot,** is the condition in which this arch is diminished or lost.

More complicated deformities result from combinations of these, the more frequent being talipes equino-varus, talipes equino-cavo-varus, talipes equino-cavus, talipes calcaneo-valgus, and talipes calcaneo-cavo-valgus.

Talipes in general results from contraction of a muscle or of muscles, or from alteration in the shape of the bones, or from contraction of the soft parts or skin. In some varieties the exact action of the muscles in producing the deformity is easily understood, as, for example, in the development of talipes equinus from the unopposed action of the gastrocnemius and soleus. In other cases, such as pes cavus, the exact mechanism of production of the deformity is not at present certain. In pes planus there is a yielding of the ligaments; the cause of this condition must be considered separately. Excluding it the varieties of talipes, according to their causation, may be stated thus:—

Congenital talipes.

Paralytic talipes due to a lesion of the lower motor neurone, either poliomyelitis, or neuritis, or nerve injury, etc.

Spastic talipes resulting from spasm of muscles, most often as the result of a lesion of the upper motor neurone.

Talipes due to injury of a muscle with resulting contraction.

Talipes resulting from alteration in shape of the bones—for example, that which follows arrest of growth of the tibia, and talipes valgus resulting from malunion of a Pott's fracture.

Talipes resulting from scarring, either scars of the skin or deeper scars, or fibrosis around the ankle or foot after an injury which has been kept fixed for a long time, *e.g.*, when a fracture of the tibia has been fixed for a long time with the foot in the equinus position.

Adaptive talipes is described as occurring in short-leg. The foot, being held constantly in the equinus position, is said to become deformed; this is extremely rare, if in fact it ever occurs. Most patients with a short leg can walk upon the toe for many years without any fixed deformity arising.

Talipes decubitus—another doubtful form. As the result of long recumbency the foot, resting in the equinus position and kept depressed by the bed-clothes, is said to become fixed in this posture. The occasional cases in which this does occur can be explained as resulting from a subacute septic inflammation in the calf during the illness, with resulting contraction of the tendo Achillis.

The most important of these varieties of talipes are the congenital forms and those resulting from paralysis of the type of anterior poliomyelitis. These require further description, and it will be most convenient to group them under anatomical varieties.

**Talipes equino-varus.**—Talipes equino-varus is the most common of the congenital deformities of the foot, and one of the most frequent of all congenital deformities. It also occurs commonly as the result of an attack of infantile paralysis, when the peroneal and extensor muscles are weak and are overcome by the tibials and the gastrocnemius and soleus and long flexors. As a spastic deformity it is not rare, whilst it may also result from malgrowth

FIG. 80.—Congenital talipes equino-varus. Neglected case with bursæ upon the part of the foot which has borne the weight.

of the lower end of the tibia or from scarring. The following account refers to the congenital and paralytic forms :—

*Pathological anatomy.*—The chief element in the deformity is an inversion of the fore part of the foot at the mid-tarsal joint, the scaphoid being displaced inwards and downwards upon the astragalus, the upper and outer part of the head of the latter bone being uncovered. In addition, when this part of the deformity has been corrected it is found that the whole foot is plantar-flexed at the ankle-joint ; and further, in many of the congenital deformities, that the inversion is not limited to the fore part of the foot, but that it may also be evident at the ankle-joint and, in the opinion of some, even in the leg, so that when all other elements of the deformity have been corrected the foot may remain inverted.

In addition to the displacement of the bones upon each other, inevitable in this deformed position, certain of the bones may be actually misshapen. This is particularly found in old-standing and neglected cases. The most

important alterations are in the astragalus, the neck of which bone points more downwards and inwards than usual, and in the os calcis.

The tibial muscles and the tendo Achillis, and to a less extent the long and short flexors, are shortened; the peronei and long extensors are stretched. The ligaments on the inner side of the ankle-joint and on the under-surface of the foot, including the plantar fascia, are contracted.

In neglected cases the child walks upon the dorsum of the foot, the bearing point being the region of the cuboid, and over this part a bursa may form. In many congenital cases there is an associated slight genu valgum, and other congenital deformities, either in the same limb, such as stiffness of the knees, congenital dislocation of the hip, coxa vara, etc., or in other parts, may be found.

*Diagnosis.*—The diagnosis of the deformity is evident. As a rule the congenital cases can be distinguished from the paralytic cases by the history and by the discovery of paralysed or weak muscles in the latter; often the foot is cold in the paralytic cases. In congenital cases there may be a family history of the deformity, and it is not unusual to find several members of one family affected.

*Causation of congenital talipes.*—Pressure upon the feet in utero has been blamed as the cause of club-foot; the only point in favour of this is the occasional discovery of the deformity in association with constrictions produced by amniotic bands. Maternal impressions have also been given as a cause. The occurrence of the deformity in several members of a family and its association with other deformities render it probable that it must be classed as a primary error of development of which at present we do not understand the cause. There is no muscular paralysis in congenital talipes.

Fig. 81.—Congenital talipes equino-varus. First stage of treatment, showing the position of fixation in plaster.

*Treatment.*—The treatment of congenital talipes should be commenced as early as possible. Its object is first to correct the deformity until the foot can be forced into the opposite position, *i.e.*, slight talipes calcaneo-valgus, and then to retain it in this position until the bones and muscles have adapted themselves and until the foot shows no tendency to relapse. Very various methods of correction by operation and many forms of splints and special apparatus have been devised for the treatment of talipes. It will be sufficient here to describe the simple routine correction of an early case and to enumerate the most important of the operations which are used for older cases more difficult of correction.

A most important principle in correction is that of working in two stages; the fore part of the foot is first treated until it lies slightly over-corrected in the valgus position, and then when this has been attained, and when the parts have been given some weeks to readjust themselves, the equinus part of the deformity is corrected.

In the new-born infant treatment by manipulation and splinting must be commenced at once. The varus part of the deformity is overcome by daily

manipulations with the hand and a tenotomy splint applied down the outer side of the ankle and foot to maintain the best possible position.

As soon as it is evident that these methods are insufficient to correct the deformity quickly and completely, recourse should be had to operation. Under an anæsthetic the foot should be gradually moulded with the hands until the whole of the inversion, adduction and internal rotation is over-corrected, and the foot, whilst still plantar-flexed, lies in the valgus position; at the same time any overarching must be corrected by stretching out the sole. The foot is then fixed in plaster of Paris in this over-corrected position, the knee being flexed and included in the plaster in order that a fixed point may be provided from which the foot can be externally rotated. After an interval of six weeks a second manipulation is performed to correct the equinus part of the deformity; in young children this can be accomplished by steady stretching with the hands without division of the tendo Achillis. This tendon should only be divided in older children, and then only when every effort has been made to correct the deformity by manipulation alone. Division or lengthening of the tendo Achillis definitely weakens the action of plantar flexion of the foot by shortening the calf muscles; it should be reserved for cases in which it is absolutely essential in order that the deformity may be fully corrected. After this second correction the foot is again fixed in plaster with the knee flexed, being maintained in the fully everted and abducted position and dorsally extended beyond the right angle. This position is kept for six weeks, and at the end of that time a further plaster may be required if the foot tends to flex and invert as soon as the second one is removed. Some surgeons divide the tibialis anticus and posticus tendons, the plantar fascia and tendo Achillis during these corrections. In young children this is not necessary. In obstinate cases in older children it may be necessary to divide the plantar fascia in the first stage of correction, and the tendo Achillis in the second stage. The tibial muscles are best left alone. Correction can be performed without dividing the tibialis anticus, and this muscle may be wanted later for transplantation. It is impossible to divide the tibialis posticus subcutaneously with any certainty. This muscle is certainly an obstacle to correction in some late and resistant cases; in them it is best dealt with by open operation as described below. After the removal of the last plaster the foot should be held in a right-angled tin shoe until such time as the child starts to walk. Then if the foot is placed flat upon the ground and has no tendency to invert, an ordinary shoe may be worn. If, however, there is a tendency for the foot to turn on to its outer side, a boot with an inside steel to the calf and a varus T-strap should be worn until this tendency disappears. The best test to apply in deciding whether any further splinting or instrumental treatment is required is to induce the child volun-

FIG. 82.—Congenital talipes equino-varus. Second stage of treatment, showing the position of fixation in plaster after division of the tendo Achillis.

tarily to dorsally-extend the foot. If in this movement the foot can be everted, the treatment may be discontinued. If it inverts, further treatment is required.

The above account refers to a simple case in which no difficulties are experienced. Apart from relapse, which is frequent after full correction has been obtained, and which is due to some defect in fixation or in the after-treatment, the chief difficulties met with are—resistance to the actual correction so that this is not possible with the hand (this is most often the case in congenital cases in older children), persistence of the inversion of the foot after otherwise full correction, and failure of the extensors and peronei to recover their power.

Fig. 83.—Thomas's wrench.

The first difficulty is best met by the use of Thomas's wrench, a screw-wrench with one fixed and one movable bar; the foot can be held in any position between these bars and great force applied to the correction of the deformity.

Persistent inversion is usually due to imperfect correction in the first stage, the varus part of the deformity not having been corrected, or the knee not having been included in the plaster. When present it may be dealt with by the application of a walking apparatus extending to the waist, by which means eversion can be secured, or even in severe cases by osteotomy or osteoclasis of the lower part of the tibia, the bone being twisted after being broken.

Occasionally in congenital cases the extensor muscles and the peronei fail to recover their power; this may be met by transplantation of the tendon of the tibialis anticus to the region of the cuboid.

Paralytic talipes equino-varus can be treated in exactly the same way as the congenital deformity; as a rule correction of the deformity is easy. Transplantation is of course more frequently indicated.

*Operative measures for severe cases.* — Severe relapsed or neglected cases are best treated by repeated attempts to correct with the wrench, and open operation should be kept for very resistant cases. In these it is found by dissection that the most important obstacle to correction is the existence of a dense mass of fibro-cartilaginous tissue between the scaphoid, which is subluxated inwards on the head of the astragalus, and the internal malleolus. This represents the insertion of the tibialis posticus and the internal and inferior calcaneo-scaphoid ligaments. It should be removed. Secondly, correction of the position of the os calcis beneath the astragalus may be hindered by the internal lateral ligament of the ankle-joint, which requires division. Finally, there is often some deformity of the bones themselves. In the past this deformity has perhaps been regarded as of more importance than it merits. The anterior part of the astragalus and os calcis sometimes point more inwards than they should. The astragalus does not as a rule need division, but a transverse osteotomy of the os calcis immediately behind the calcaneo-cuboid joint may be required. In the worst cases, then, a composite operation

in which the internal lateral ligament of the ankle-joint is divided, the mass between the scaphoid and internal malleolus removed, and the anterior part of the os calcis cut through, will entirely correct the varus element in the deformity. If any equinus remains, lengthening of the tendo Achillis, and perhaps section of the posterior ligament of the ankle-joint, may be necessary. Fixation of the foot in the fully-corrected position can then be carried out.

The other classical operations are astragalectomy, the removal of a wedge-shaped portion of the tarsus from the outer side, and removal of the cuboid; these are bad, for they seriously shorten the foot and interfere with the tarsal joints. Ogston's operation consists in the enucleation of the central part of the astragalus, the foot being then corrected by crushing the shell of bone left. This operation is only possible in young children, and in them it is unnecessary.

**Talipes equinus.**—Talipes equinus is very rarely congenital; it is most often the result of an attack of anterior poliomyelitis, and the main factor in producing the deformity is the contraction of the tendo Achillis. But contraction of the soft parts, or deformity of the bones, is also important, particularly in those cases which result from scarring or from fractures in the region of the ankle.

The chief part of the deformity is situated at the ankle-joint, but in severe cases there is often also considerable displacement of the fore part of the foot at the mid-tarsal joint. The condition in which the foot cannot be (dorsally) extended beyond a right angle is important, and is often called *rectangular talipes*.

Talipes equinus is corrected by division or lengthening of the tendo Achillis, and if necessary by subsequent wrenching. Tenotomy of the tendo Achillis is performed from the inner side a short distance above the lower attachment of the tendon, the tenotome being passed deep to the tendon and the cut made towards the skin. For all except quite young infants, however, this form of tenotomy has been completely replaced by subcutaneous lengthening of the tendon, introduced by Bayer. The tenotome is inserted from the inner side close to the lower attachment of the tendon and passed half-way across the tendon between it and the skin; the blade is turned inwards and the inner half of the tendon divided. The tenotome is then again introduced at a distance of about 1 to 1½ inches higher up, this time from the outer side; the outer half of the tendon is similarly divided at this level. By gentle pressure the foot can then be forced up, the two halves of the tendon sliding upon each other, but remaining attached along a central line. By this operation the extent of lengthening of the tendon can be regulated, and there is not as much tendency to recontraction.

*Union of divided tendons.*—Division of a tendon is followed at once by retraction of the proximal end by the muscle, the sheath being filled with blood-clot. The retraction of the muscle passes off in the course of one or two days, at the end of which time the organisation of the intermediate clot has already commenced. The older school of tenotomists considered that it was bad to correct the deformity fully until this stage, as they believed that wide separation before the muscle had relaxed would result in non-union. We now know that this is not so, and that full correction may be made at once. Organisation of the intermediate clot proceeds rapidly; at the end of three weeks there is well-organised fibrous tissue present, and at the end of six weeks the tendon is fully re-formed and strong enough to carry on its work. Unless the tendon is kept on the stretch during this period the newly-formed fibrous tissue will retract to such an extent as to obliterate completely the gap left at the time of the operation, so that no lengthening will

result. In spastic conditions the retraction of the muscle may persist throughout the period of repair, and thus excessive lengthening of the tendon may result; for this reason it is the rule never to divide the tendo Achillis completely in a spastic limb, but always to lengthen it.

**Talipes calcaneus.**—As a congenital deformity talipes calcaneus, usually combined with some degree of valgus, is common. It is the form of talipes specially liable to occur in conjunction with spina bifida. It is as a rule a postural deformity. Forcible correction is seldom necessary, and the only treatment required is the application of a splint to hold the foot in the inverted position until the child begins to walk. If the deformity is still present at that time, a support must be fitted to secure that the child walks upon the outer side of the foot and gets the toes fairly on to the ground. In cases in which the deformity is fixed a preliminary manipulation, and fixation in plaster, is required.

Paralytic talipes calcaneus is an important deformity which results from loss of the gastrocnemius and soleus; it is usually combined with talipes valgus. In neglected cases the fore part of the foot becomes plantar-flexed by the long and short flexors, a severe cavus deformity being added. In order to prevent this the foot must be retained for a long period in the plantar-flexed position in the hope that the posterior muscles will regain their power. If they do not, transplantation of the long flexor tendons and of the peroneus longus into the insertion of the tendo Achillis may be carried out, the tendo Achillis being at the same time fixed to the back of the tibia so that it acts as a posterior ligament to the ankle-joint. By this means the weakened muscle is reinforced, and at the same time the action of the long flexors in producing cavus and of the peroneus longus in producing valgus is removed. In older cases when cavus deformity is present the best treatment consists in the performance of Whitman's operation (see *Paralytic Deformities of the Lower Limb*).

FIG. 84.—Talipes calcaneus. The long flexors are producing a severe cavus deformity.

**Pes cavus.**—Pes cavus is in most cases an acquired deformity. It is undoubtedly a muscular deformity, the probable mechanism of its production being as follows. There is a paresis of the muscles of the leg and foot affecting chiefly the peronei and the intrinsics, particularly the interossei. One action of the peronei is to abduct the anterior part of the foot and in so doing to diminish the longitudinal arch. Loss of power in the peronei allows the anterior part of the foot to adduct, raises the arch and shortens the inner border. The chief muscles concerned in dorsally extending the foot are the tibialis anticus, peroneus tertius and extensor longus digitorum. The latter in elevating the foot tends to hyperextend the toes at the metatarso-phalangeal

joints, allowing the interphalangeal joints to remain flexed; at the same time it tends to pull the toes backwards and so to shorten the foot. Usually the interossei and lumbricals act at the same time, keeping the toes from hyperextending and the interphalangeal joints from flexing. If these latter muscles are paralysed the extensor longus digitorum hyperextends and claws the toes, and shortens the foot, producing the typical pes cavus with claw toes. It may arise, or at least be first noticed, at any time of life, but it most often commences during childhood or adolescence. One or both feet may be affected.

The foot is shortened, its anterior part is broad, the arch is high and the external border may not touch the ground. The toes are hyperextended at the metatarso-phalangeal joints and flexed at the distal joints (*claw toes*), so that the tips of the toes may not touch the ground in walking. In one type of deformity the fore part of the foot is inverted (*metatarsus varus*); in many cases there is an associated contraction of the tendo Achillis (*talipes equino-cavus*).

Fig. 85.—Pes cavus.

In the majority of cases the condition is due to some disease of the nervous system. The important known diseases in which pes cavus occurs are:—

1. Anterior poliomyelitis, the usual cause of the unilateral cases.

2. Progressive muscular atrophy of the peroneal type (Charcot, Marie, Tooth type), a frequent cause of bilateral cases. In this disease pes cavus is often the first symptom. The diagnosis is important, for the condition is slowly progressive; its progress may be delayed or prevented by proper retentive apparatus, and the disease progresses so slowly that patients are usually able to continue their work to an advanced age provided they do not become crippled by their foot deformity. In neglected and progressive cases the foot may eventually become so deformed that it resembles an untreated case of congenital talipes equino-varus. Tenotomies and forcible correction of the deformity may be freely carried out in this disease.

3. Friedreich's ataxia, another occasional cause of bilateral cases; again pes cavus may be the first symptom. For a further account of these diseases a work upon neurology must be consulted.

Only a small proportion of the cases can, however, be definitely referred to one of these diseases. There is a further large class of children who develop pes cavus which progresses to a certain stage, then shows no tendency to become worse, and is unaccompanied by other nervous symptoms and signs. In some of these there is a tendency for several members of a family to be affected, and it is worthy of note that the last two nervous diseases named are family diseases.

Apart altogether from these classes, pes cavus may result from rheumatoid

arthritis of the tarsal joints, and it is also found in a slight form as the result of the wearing of tight boots with high heels; the latter form is termed in America *hump-foot.*

The chief disability in pes cavus results from the heavy tread upon the heads of the metatarsal bones; callosities may form beneath these, and metatarsal pain is common; corns upon the clawed toes are also troublesome.

In moderate cases the proper care of the corns and massage of the feet to retain their full mobility is sufficient to relieve the symptoms. Corns are best treated by the application of a 40 per cent. salicylic acid plaster and subsequent paring. If the feet are stiff, movement of all the joints under an anæsthetic, and subsequent massage, will relieve pain. In severe cases the deformity should be corrected as far as is possible by tenotomy of the plantar fascia, wrenching, and fixation in plaster. If there is associated equinus, this must be corrected at a subsequent operation. The tendo Achillis should not be divided in these cases unless it proves impossible to dorsal-flex the foot to less than a right angle by other means.

**Flat-foot and weak-foot.**—By flat-foot is meant a diminution or disappearance of the internal longitudinal arch; it is usually associated with a certain amount of valgus, *i.e.*, of eversion and abduction of the fore part of the foot at the subastragaloid and mid-tarsal joints. But valgus without any breaking down of the arch is also frequent as a postural deformity; it should be carefully distinguished, as, although the causes are the same, the cure of the condition is much more simple when the arch is intact.

Flat-foot and valgus occur at all ages. In infants the arch of the foot is only developed after the child commences to walk. During the second and subsequent years flat-foot or valgus are frequently found either as a persistence of a congenital valgus or as the result of late development of the arch, often the result of the muscular weakness of rickets. In older children and in adolescence flat-foot and valgus occur as static deformities of this period, and in adults they are frequent as the result of occupations which require much standing. In addition the arches of the feet may give way in older subjects as the result of rapid increase in the body weight, whilst paralysis of muscles (tibials) and softening of the ligaments in arthritis of the tarsal joints are other important causes.

*Degrees of deformity.*—In any case of valgus the first important point to be determined is the condition of the longitudinal arch; an estimate of this formed by the eye is apt to be deceptive. Many patients are treated for flat-foot in whom the arch is intact or is even excessive. A print of the foot may be easily obtained by making the patient tread upon a pad which has been soaked with a solution of potassium ferrocyanide, and then immediately upon a paper which has been impregnated with ferric chloride and allowed to dry. A print of the part of the foot which is in contact with the ground in Prussian blue results. Fig. 86 shows prints of feet with a normal arch, with the arch lost, and with an excessive arch (*pes cavus*).

Whether the arch is lost or not, three stages of deformity may be recognised. In the first degree the patient can in tip-toeing pull up the arch of the foot with his tibial muscles. In the second degree he is unable to do this, but if he sits down the foot can be inverted by the surgeon and an arch reconstructed. In the third degree inversion of the foot is impossible. The cause of the fixed condition of the foot in the third degree of deformity varies. In early cases there is muscular rigidity, the peronei and extensor muscles being contracted; such rigidity will disappear with rest or under an anæsthetic. In cases of longer duration, in addition to this muscular contraction

there are periarticular adhesions, which must be broken down before the foot can be inverted. In older cases still the bones may be actually deformed, and it may be difficult or impossible to reduce the deformity.

*Symptoms.*—In children there may be no pain or disability; advice is sought on account of the deformity or on account of a secondary protective habit of turning the toes in. In older patients there may be a simple aching under the arch of the foot and on the inner side; in the most painful varieties of flat-foot, however, those in which there is muscular spasm, the pain extends up the outer side of the leg up the fibula even as far as the knee.

As a rule, in simple flat-foot there is no swelling and there are no inflammatory signs; but, as already stated, arthritis of the tarsal joints is one cause of flat-foot, and the inflammatory signs of this may be present. The determination of the presence of such an arthritis is an important preliminary to the treatment of the patient. It is most likely when present to be due to infection

Fig. 86.—Foot-prints: *a*. Normal foot. *b*. Pes cavus. *c*. Flat-foot.

from some septic focus—for example, the tarsal joints are not infrequently the site of an arthritis due to the gonococcus, or to sepsis from pyorrhœa. Such a septic arthritis may leave a very severe form of flat-foot in which there are actual intra-articular adhesions.

A further important point for investigation is the presence of any painful spot upon the foot, such as an inflamed corn; this, by inducing unusual attitudes, may put too severe a strain upon the muscles which should hold up the arch. Hallux rigidus, by preventing the proper elevation of the arch in walking, may also assist in causing flat-foot.

*Treatment.*—The first step in treatment must be the removal of any possible cause, such as a painful spot, and the treatment of such a condition as arthritis. Excluding such inflammatory cases, the principle of treatment is the reduction of the rigid third degree into the second, the support of the weak second degree until it is reduced to the first, and the cure of the first degree by appropriate strengthening of the muscles.

In many cases the rigidity will disappear as the result of a few days' rest; if it does not, it must be reduced by manipulation under an anæsthetic. The

patient being anæsthetised to the stage of muscular relaxation, the foot is forcibly inverted, Thomas's wrench being used if necessary, and is then fixed in the fully-inverted position in plaster of Paris. It is retained in this position until the spasm has disappeared. The foot is then in the condition of second-degree flat-foot.

At this stage it is useless to give the patient active exercises—his muscles are insufficiently strong to enable him to carry them out. He may, however, be treated by massage and resisted movements. For walking purposes it is also necessary to support the arch, so that the weakened muscles shall not be constantly stretched. The simplest method of supporting the muscles is to thicken the inner side of the sole and heel of the boot so as to throw the

FIG. 87.—Flat-foot, first degree; upon tip-toeing the arch of the foot reappears.

foot on to its outer border; with this may be combined a long heel reaching forward upon the inner side beneath the instep, although this is unnecessary in good boots made with a strong waist. If this method is insufficient, as shown by the turning over of the boots in spite of it, an outside steel support to the top of the calf with valgus T-strap must be added.

Steel arch supports fitted inside the boot are much used. Those mostly sold by bootmakers are very comfortable for patients whose feet get tired easily, or who have very slight flat-foot. If second-degree flat-foot is present, however, they are either not tolerated or else they force down the waist of the boot instead of supporting the arch. The best form of support is one made to fit a cast of the foot taken with both longitudinal and transverse arches reconstructed. It should reach from the anterior part of the heel to immediately behind the heads of the metatarsal bones and should be made of some material which does not rust, such as phosphor-bronze.

As soon as the patient is able to raise the arch voluntarily in tip-toeing, treatment by active exercises must be added, and when possible supports should now be dispensed with. The exercises which are most useful are :—

1. Stand with heels together and toes separated by an angle of 60 degrees ; rise on tip-toe ; separate heels, keeping toes firm on ground ; sink upon heels.

2. Stand as before ; rise on tip-toe ; bend knees outwards and sink slowly until the position of squatting upon the heels is almost reached ; rise until knees are straight ; lower heels.

3. Walk upon tip-toe.

4. Stand as before : tip slowly over as far as possible on to the outer side of the feet ; return to original position.

5. Sitting, cross one knee over the other and carry out circumduction of the anterior foot, moving the toes downwards and inwards.

In this description of treatment no notice has been taken of any fact except the degree of the deformity. In determining the method to be adopted the other facts of the case must be considered. Treatment for flat-foot in the presence of an infective arthritis of the tarsal joints will be unsuccessful ; whilst if the arthritis is tuberculous, as it may possibly be, a catastrophe may result. Apart from these considerations, the treatment which is appropriate to a youth of sixteen may be entirely unsuited to a middle-aged man of heavy build. All the circumstances of the patient, including age, weight, occupation, etc., must be carefully considered.

Fig. 88.—Hallux valgus, with bursa.

**Hallux valgus.**—By hallux valgus is meant a deviation of the great toe inwards towards the mid-line of the foot at the metatarso-phalangeal joint. This deformity most often arises during adolescence or in early adult life, although advice is only sought later when an inflamed bursa has formed over the prominent joint. It is usual to blame tight-pointed boots for the development of the deformity, but it is by no means certain that this is true. The boots no doubt increase the obliquity of the toe and produce the bunion, but hallux valgus may occur in those who have never worn tight shoes.

In cases of moderate severity it is sufficient to hold the toe straight and prevent progress of the deformity and pressure upon the joint. Stockings with a separate toe must be worn, the fore part of the boot must be wide, and an india-rubber toe-post may be used to separate the first and second toes. A spring splint, which is applied along the inner side of the toe, may be worn at night to hold the toes apart.

If the condition is disabling or gives rise to much pain, it should be treated by operation. The only satisfactory method is a complete removal of the head of the first metatarsal bone ; a flap consisting of a part of the wall of the bursa, or if this is absent of subcutaneous tissue, should be turned in over the cut end of the bone. As soon as the wound is healed the toe should be strapped in such a way as to keep it abducted and circular strapping applied around the transverse metatarsal arch. In this the patient is allowed to walk until no further tendency for the toe to adduct remains.

**Hallux rigidus.**—Hallux rigidus is a stiffness of the great-toe joint arising usually during adolescence. In later stages the joint may become deformed, the great toe being permanently flexed.

Pathologically, the process is an osteoarthritis of the joint, the cause of which is unknown. Apart from local pain and discomfort, the rigidity of this joint, particularly the lack of extension movement, prevents the proper action of the foot in walking, and may indirectly lead to the development of flat-foot.

Any possible cause of the condition must be removed, septic foci being looked for and the joint carefully protected from pressure. Shoes with fairly heavy soles should be worn to prevent excessive movement of the joint, and a metatarsal bar may be fitted under the boot. When there is much pain or disability an excision of the head of the first metatarsal may be carried out as for hallux valgus.

**Hammer-toe** is a contraction most often of the second toe, in which the second phalanx is flexed permanently upon the first and partially dislocated downwards. There is usually a corn, and sometimes a bursa, upon the dorsal surface of the joint. The deformity usually arises during adolescence. In the early stages wearing a splint may successfully straighten the toe. In later stages an operation is necessary. That usually performed consists in the excision of the distal half of the first phalanx, and removal of the articular cartilage from the base of the second phalanx, the toe being afterwards fixed upon a splint until union has taken place between the stump of the first phalanx and the second phalanx. In slight cases subcutaneous division of the flexor tendons and of the lateral ligaments of the joint will enable the deformity to be reduced. Amputation of the toe is often performed; the objection to this is that there is sometimes an associated hallux valgus, which may be increased by the absence of the second toe. The chief objection to the ordinary operation of partial excision of the phalanx is that the after-treatment by a splint lasts for several weeks. Excision of the whole first phalanx is a satisfactory operation which requires no after-treatment; its only defect is that it somewhat unduly shortens the toe.

FIG. 89.—Hammer-toe. Section through centre of second toe, showing the subluxation of the second phalanx and a bursa above. (St. Bartholomew's Hospital Museum.)

**Metatarsalgia (Morton's disease).**—Metatarsalgia is the name given to a spasmodic pain felt in the region of the head of the fourth metatarsal bone and in the neighbouring sides of the third and fourth or fourth and fifth toes. The pain is very characteristic; it starts in the situation mentioned, extends rapidly to the fourth toe, and thence to the whole foot. It is described as neuralgic in character, and is so severe as completely to prevent walking. In the early stages it may be relieved by the removal of the boot and manipulation of the fore part of the foot. Pain in the region of the metatarsal heads is not uncommon, particularly in cases of pes cavus, and these more vague pains must be carefully distinguished from true metatarsalgia. In the latter the pain can always be brought on by gripping the foot transversely immediately behind the heads of the metatarsal bones and compressing it laterally, the fourth metatarsal bone being at the same time pressed down from above.

In some cases the pain commences after an injury; in others it arises spontaneously. The arch formed by the heads of the metatarsal bones is always found to be broken down, and the pain is, it is supposed, produced by the nipping of the digital nerve between the heads of the third and fourth or fourth and fifth metatarsals.

In some cases support to the transverse arch by strapping applied in a circular manner around the fore part of the foot will relieve the pain; in others a support behind the heads of the third and fourth metatarsals may be efficacious. In persistent cases excision of the head of the fourth metatarsal will always effect a cure; but care must be taken that the case is one of true metatarsalgia, for such an operation will not relieve the pain in the metatarsal region of an over-arched foot.

**Contracted little toe.**—As a congenital deformity the little toe is not infrequently hyperextended and adducted over the fourth toe. Such a toe may become the site of a painful corn. A simple tenotomy is not sufficient to cure the condition. There is invariably some contraction of the skin. A plastic skin operation is necessary, or the toe may be amputated.

## Section IV.

### INJURIES AND DISEASES OF TENDONS AND TENDON SHEATHS, FASCIÆ, BURSÆ AND MUSCLES.

#### Injuries to Tendons.

These may be divided into *Ruptures* and *Dislocations*.

**Ruptures of tendons** may be due to direct or indirect violence. The commonest form of laceration due to direct violence is that seen affecting the tendons on the anterior aspect of the wrist- and ankle- joints. The tendons in these situations are most commonly injured as the result of a fall through glass or division by a knife. A single tendon only or many of a group may be involved. The surgeon intentionally divides a tendon in performing the operation of tenotomy.

Indirect violence may bring about a rupture in two ways. In the case of a healthy muscle a sudden violent muscular contraction is the usual cause. In some cases, however, a predisposing factor, such as erosion from rubbing over an osteophyte in the region of a joint, necrosis resulting from involvement in tuberculous arthritis, or primary suppurative teno-synovitis, renders the tendon more liable to rupture from minor violence.

A tendon may rupture either at the point of its junction with its muscular belly or its insertion into the bone: in the latter situation a portion of the bone may be torn off also.

*Symptoms.*—When there is a large open wound the division of tendons is usually obvious. In the case of small wounds the same symptoms as in rupture without an open wound are present.

The patient may feel a snap or even hear a noise; there is often a sensation of having been hit sharply with some hard object. This is accompanied by severe pain, with loss of function of the affected muscle; later, a patch of ecchymosis is often seen in the region of the rupture. The muscle on the proximal side of the lesion retracts and forms a soft swelling, with a depression below.

The following are among the commoner tendons subject to injury:—

The *plantaris* usually ruptures while carrying out some violent leg exercise, as in tennis; the patient feels a sudden pain in the calf of the leg, often causing him to fall.

*The biceps.*—The long tendon of this muscle is torn as it passes over the head of the humerus in the bicipital groove. It is often previously eroded by osteophytic outgrowths of the bone in osteoarthritis or tuberculosis of the joint.

The *quadriceps extensor* tendon ruptures just above its insertion into the patella. The muscle in this case frequently does not retract owing to the lateral expansions remaining intact. An effusion of blood into the joint occurs.

The *ligamentum patellæ*, when torn, allows the patella to retract upwards on to the thigh, leaving a large gap below through which the lower end of the femur and the upper end of the tibia can readily be felt.

The *tendo Achillis* sometimes ruptures as the result of dancing, but seldom retracts owing to its adhesion to its sheath.

The *flexor tendons of the forearm* are torn, but remain attached to a finger which is pulled off as the result of being caught in a cog-wheel of a machine, a condition spoken of as "avulsion of the finger." This is an important condition, for, although the wound is low down at the junction of the finger with the hand, there is an effusion of blood along the line of the tendon high up into the forearm, which may become infected and thus set up a deep cellulitis of a serious nature. Great care is required in dealing with this condition: early free incision is demanded should the signs of sepsis supervene on the injury.

The *extensor tendons of the fingers* opposite the last interphalangeal joint rupture as the result of direct injury, allowing the last phalanx to flex and rendering extension impossible. The curious appearance of the finger has led to the term "mallet finger" (see p. 248).

The *treatment* in the case of an open wound is always primary suture. If important tendons are affected, especially if wide separation exists, open operation with attempts at repair should always be carried out. If the wound has been allowed to heal in the case of finger tendons secondary repair is usually required. This is often difficult owing to the formation of scar tissue. In other cases, when the tendons are in close apposition or are of minor importance, fixation by splinting and, later, massage and gentle movements are indicated.

**Dislocations of tendons.**—As the result of rupture of the bands of fibrous tissue which keep them in position, tendons may be dislocated from the grooves in the bone in which they usually lie. The tendons most commonly affected are the peroneus longus, the biceps of the arm, and the thumb muscles. The accident follows a sudden violent action with the limb in a position favourable for the dislocation to occur. It is accompanied by severe pain and loss of function. A swelling appears and the tendon may be felt out of place. The condition is very liable to recurrence after replacement. Some people can voluntarily dislocate the tendon of the peroneus longus.

*Treatment.*—Fix the limb after reduction of the tendon with a pad pressing over the site for six weeks. If the condition cannot be reduced, or recurs, and the disability demands treatment, an open operation should be performed and a flap of periosteum turned down and fixed over the tendon. In some cases a portion of the torn sheath can be utilised.

## Inflammations of Tendon Sheath.

**Simple teno-synovitis.**—This condition is commonly the result of overuse or a sprain; it is sometimes ascribed to gout or rheumatism. It may be either acute or sub-acute in its onset. The patient complains of pain, and shortly after notices that attempted movement causes creaking along the site of the affected tendon sheath. This is due to inflammation and subsequent roughening of the lining synovial membrane; in severe forms the skin may redden. After a time the creaking disappears and is replaced by the appearance of an elongated swelling outlining the extent of the sheath. If suitably treated this disappears and complete resolution follows. If allowed to persist adhesions take place and stiffness of the limb may result. The tendon sheaths of the forearm and around the ankle-joint are most commonly affected.

*Treatment.*—In the early stages rest on a splint with the application of cooling lotions—*e.g.*, lotio plumbi, with or without belladonna—or hot

fomentations should be applied to relieve the pain. After the acute symptoms have subsided, massage and gentle passive and active movements should be advocated to prevent the formation of adhesions. If the fluid persists counter-irritants should be tried, or even aspiration; pressure in the form of a wristlet is often efficacious. The cause of the condition should be removed.

**Infective teno-synovitis.**—*Acute infections* are due to pyogenic micro-organisms which reach the tendon sheath either by the direct route, as through an open wound, or by direct spread from a neighbouring lesion. Hæmatogenous infection without an obvious primary focus may also arise. Acute inflammation of the sheath follows its involvement, the condition being exceedingly prone to spread rapidly and involve the whole of the affected structure. It is important in this connexion to have a knowledge of the exact anatomical extent of the sheaths, which are often complicated structures, especially in the case of the finger and hand tendons. The infection almost invariably ends in suppuration, converting the sac into a bag of pus; the tendon itself is very prone to slough and rupture. Owing to the frequent proximity of these sheaths to the joints or bones the latter are liable to suppurative arthritis, periostitis, and osteomyelitis. Lymphangitis and lymphadenitis are usually associated, and the condition may terminate in septicæmia and pyæmia. The constitutional symptoms may be very serious.

*Treatment.*—This should always be operative. If possible, the sheath should be incised before suppuration has occurred or before it has involved a large extent of the sheath. An attempt to carry this out without a general anæsthetic invariably ends in disaster. Deliberate exposure of the sheath for the whole of the area involved should be aimed at. If this is done the serious results above mentioned will be avoided, and the subsequent deformities of contracture and loss of function limited. The limb should always be supported on a splint.

The after-treatment consists in using the ordinary methods indicated in infective processes, with special care to prevent deformity and loss of power of the tendon.

**Whitlow.**—In the case of a finger tendon sheath, the infection may arise from a suppurative focus of the nail-bed (paronychia), a subcutaneous pustule arising from a prick, or from a primary suppurative periostitis or osteomyelitis of one of the phalanges. These suppurative conditions of the fingers or toes, including infective teno-synovitis, are commonly termed "whitlows or felons." The tendon sheath infection is the most important factor in this condition. The lesions are either staphylococcal or streptococcal in origin, the latter giving rise to the more serious conditions. The more superficial lesions, those around the nail-bed especially, can be avoided by keeping the hands and nails clean and preventing small particles of dirt or pus from collecting around the margins. The lesions are commonly seen in those doing surgical work, and most frequently during periods of ill-health.

*Paronychia* is recognised by an attack of acute pain in the region of the nail-bed, followed by a small hot, red, tender and throbbing swelling; fever is often present; suppuration soon follows, pointing by the side of or under the nail.

*Treatment.*—In the early stages Bier's congestive treatment or cupping often causes a potential whitlow to abort. If not, a general anæsthetic is necessary, and an incision is made until pus is found; if it has tracked under the nail, but the whole of the cavity can be exposed, a small notch should be made in the nail; if this is impossible, the nail should be removed. The after-treatment of acute suppurative lesions should be adopted.

The *synovial or thecal abscesses* are usually seen in connexion with the flexor tendons, and may easily be recognised by the fact that there is an acute suppurative lesion along the site of the tendon involved. The lesions of the thumb and little fingers are the most important owing to the anatomical connexions of the sheaths, palmar abscesses of an extensive nature frequently following.

*Periosteal whitlow* is usually connected with the distal phalanx. It is prone to infect secondarily the tendon sheaths. The symptoms are those of deep throbbing pain without any obvious involvement of the superficial tissues. Deep fluctuation may be felt. General symptoms are not usually severe. Incision is frequently the only means of making an exact diagnosis. Necrosis of the bone almost invariably follows this condition.

*Cellulitis of the finger.*—This varies in degree from a mere pustulation to a diffuse cellulitis involving deep tissues. The signs and symptoms are those of the same condition in other parts of the body. Its importance lies in the difficulty of diagnosis between it and teno-synovitis. One sign is often useful, namely, that in the latter condition there is inability to move the last phalanx, whereas this power remains quite free in cellulitis.

*Gonococcal teno-synovitis* may be either of the acute or chronic type. It should be treated as above with, in addition, special attention directed to the urethra.

*Tuberculosis teno-synovitis.*—This may be a primary lesion of the tendon sheath or secondary involvement owing to its proximity to a tuberculous joint.

It is most commonly seen in the condition spoken of as "compound ganglion," which may occur either in connexion with multiple flexor tendon sheaths of the palm of the hand or those around the ankle-joint.

The synovial membrane becomes swollen and pulpy, exhibiting fringes and often the appearance of tumour formation; the fluid content of the sac may be clear, caseous, or purulent; melon-seed bodies are also frequently found. Tubercle bacilli can sometimes be demonstrated in the fluid. On examination a swelling will be found in the region of the sheaths affected outlining their anatomical extent. In the compound palmar ganglion it extends above and below the anterior annular ligament, thus giving to it an hour-glass appearance.

In the dry or fungous form, as it is called, the swelling will be doughy or soft in places, if suppuration is occurring. In the wet form fluctuation will be obtained. If melon-seed bodies are present the crepitus characteristic of the condition will be recognised. The tendon in some cases moves freely in the sheath; at other times it is destroyed and its function is lost: the movements of the joints are as a rule unaffected unless the synovial affection is secondary to tuberculous arthritis. Aspiration of the lesion and bacteriological examination of the fluid is often helpful. In the later stages the skin may become involved and sinuses form, secondary infection commonly resulting. An X-ray picture should always be taken to exclude the possible presence of a primary focus in the underlying bones.

*Treatment.*—The ordinary palliative measures for tuberculous lesions should be tried in the early stages, including fixation of the part in a celluloid splint or plaster; fresh air and sunlight, nourishing diet and stimulating drugs, especially iron and cod-liver oil, should be advised. Tuberculin should also be tried. X-ray treatment meets with moderate success. Bier's congestion method can be tried. If these fail operative measures must be adopted. In the fungous form incision, curetting, swabbing with iodoform emulsion, closure of the wound, and rest on splints may be tried. Drainage should not

be used. At other times complete excision of the diseased structures is indicated. The application of X-rays is often efficacious as a means of after-treatment.

In the serous, caseous, or suppurative forms, apart from secondary infection, the fluid should be evacuated by aspiration, repeated if necessary on several occasions.

In the extensive forms of the disease amputation may be necessary, especially if amyloid disease or septicæmia supervene.

The result in favourable cases may be complete resolution, but stiffness of the fingers or toes commonly ensues.

*Syphilitic teno-synovitis* is a rare condition which may occur as an effusion into the synovial cavities during the secondary stage or as gummata in the tertiary stage. The condition responds to antisyphilitic remedies.

**New growths** of tendon sheaths are rare. Lipomata around the sheaths are sometimes met with, and frequently send out finger-like processes into the surrounding tissues and along the tendon. The diffuse palmar lipoma is a structure of this nature. Fibromata, endotheliomata and sarcomata also occur.

**Simple ganglion or hygroma.**—A ganglion is a fluid swelling which occurs in connexion with a tendon sheath, especially on the dorsal aspect of the wrist. Ganglia are also found in connexion with other tendons, *e.g.*, on the anterior aspect of the wrist, in the palm or around the ankle-joint, and in relation to the connective tissues of the capsules of joints. Formerly these structures were considered to be protrusions of the synovial membrane through the tendon sheath. It is now thought, however, that they are in reality tumours of the connective tissues forming the tendon sheath which have undergone mucoid degeneration. There is frequently a history of trauma preceding their appearance. The cysts, which contain clear gelatinous fluid, often have communications with the interior of the tendon sheaths or joints, probably of secondary formation. They are frequently multiple, exhibit a tendency to disappear spontaneously, and seldom reach a very large size.

The commonest symptom is a feeling of weakness of the wrist. A smooth globular swelling is found which moves laterally, but not along the line of the tendons; it is often fixed to underlying structures, but not to the skin; it is translucent and, unless very tensely distended, fluctuates.

*Treatment.*—Unless giving rise to trouble or of large size no treatment is required. The fluid may be dispersed by placing the hand on some rigid structure and hitting it sharply with a heavy object such as a book; firm pressure by means of a bandage must be subsequently applied. A tenotomy knife may be inserted into the sac, thus allowing the fluid to escape; at the same time the wall of the sac is scraped with the point of the knife. The fluid may be withdrawn in a hypodermic syringe and some tincture of iodine or other irritating substance injected into the cavity.

The best method of treatment, however, consists in excision of the ganglion. This must be carried out carefully so as to secure complete enucleation. Care must also be taken to avoid opening an underlying joint cavity.

In the after-treatment early movement is indicated. Whichever method of treatment is adopted, recurrence is exceedingly prone to take place.

**A compound ganglion** is formed by the dilatation of the sheaths of several tendons with fluid. It may be due to trauma, but most frequently results from tuberculous infection as above described. It is most commonly seen in connexion with the tendon sheaths of the palm of the hand and flexor

aspect of the wrist-joint, hence the term "compound palmar ganglion." It is also seen around the ankle and tarsal joints.

The diagnosis and treatment of this condition have already been described

## Affections of Fasciæ.

Fasciæ are liable to affections similar to those found in other tissues, but to a less extent. The commoner conditions are associated with the results of lesions in other structures, *e.g.*, stretching and contraction. The stretching of ligaments is seen around joints, into which there have been effusions of fluid, especially in chronic inflammation, *e.g.*, osteoarthritis and tuberculosis. This leads to a loss of power in the limb and subsequent deformities. It is rarely possible to remedy the condition, though sometimes resting the part by the use of splints tends to a tightening of the ligaments, but at other times an arthrodesis of the joint is necessary.

**Contractures.**—These are seen in certain joint conditions. For example, the anterior ligaments of the spine become contracted in healed spinal caries; the ilio-tibial band in long-standing cases of hip disease; the lateral ligaments of the interphalangeal joints of the toe in cases of hammer-toe; the plantar fascia in deformed conditions of the feet.

The gonococcus is prone to attack fasciæ and set up inflammation, which is characterised by pain during the acute stages and contracture in the later stages.

**Dupuytren's contracture.**—This is a condition of flexion of one or more fingers, due to contraction of the palmar fascia and its prolongations.

It is most commonly seen in men, and affects the ring and little fingers in that order of frequency. Usually found in persons over forty years of age, it has been seen in quite young adults. Both hands are frequently involved. Its cause has been variously ascribed to trauma, chronic inflammation, gout, rheumatism, and syphilis. The possibility of infection through the palm of the hand is often regarded as the cause in those whose occupation entails pressure upon the palm of the hand, *e.g.*, gardeners, but the condition is frequently seen in those whose labour is not manual.

*Clinical signs.*—The condition is very chronic and always slowly progressive. In the first instance there appears a small fibrous nodule in the palm of the hand, followed after a time by inability to extend the affected finger fully. As the finger is drawn down a band appears on the palmar aspect which runs from the palmar fascia to the finger; the skin overlying the fascia is thrown into folds. At first the metacarpo-phalangeal joint is involved, and later the proximal interphalangeal joint. The distal joints are not affected, as the fascial prolongations do not extend so far. The tendons are unaffected. In extreme cases the tip of the affected finger rests on the palm of the hand. Sometimes only one finger is involved, frequently both the little and ring fingers, and occasionally others. In this way the hand is rendered more or less useless, but it is not a painful condition.

It is important to diagnose the lesion from similar deformities due to contraction of tendons, or to osteoarthritis of the finger-joints. These are usually easy to differentiate. In a contracted tendon the band can be felt running up under the anterior annular ligament, and the last interphalangeal joint is affected. In osteoarthritis the bony nodes can be felt; the two latter conditions frequently coexist.

*Treatment.*—In the early stages massage and the use of a splint applied to the dorsal aspect of the hand and finger at night-time may be tried; this

method, however, usually fails to prevent the contraction. Subcutaneous division of the contracting band and the subsequent use of splints has a similar result. The best treatment consists in exposing the band by open operation, dissecting it out carefully, and removing its attachment both to the palmar fascia and the fingers. A splint should be worn at night for at least two years after this operation. Should recurrence follow or more than two fingers be involved, the whole of the palmar fascia may be removed by a flap operation in the palm of the hand.

## Diseases of Bursæ.

There are several varieties of bursæ: (1) those constant in their situation, whose object is to act as buffers between two structures liable to press on each other (mostly between tendons and bony surfaces), or which act as cushions over certain bony eminences and protect them from external pressure (*e.g.*, the bursa over the ischial tuberosity). (2) Some bursæ are formed as protrusions from the synovial cavities of joints; they may remain permanently connected with the joint, or in the course of development become cut off from the main cavity. (3) The third group are of new formation, appearing over normal or abnormal bony prominences which are subjected to pressure or friction; these are spoken of as *adventitious bursæ*.

The recognition of these varieties is important, for certain diseases are liable to affect one type and not another; for example, tubercle is more likely to affect a bursa connected with a joint than an isolated one. In the main, however, they are all subject to the same pathological conditions.

The majority of the diseases of bursæ are dependent on injury.

**Acute simple bursitis** results from an injury as a rule, and is associated with an increase of fluid in the bursa, with local signs of inflammation. There is no evidence that the lesion is infective in origin. Amongst the more common conditions may be mentioned inflammation of the bursa between the tendon of the biceps and the tubercle of the radius, most commonly caused by unaccustomed or excessive use of the tennis racket; hence the term "tennis elbow." A similar condition is seen in the adventitious bursa, known as a "bunion," which forms over the prominent metatarso-phalangeal joint in cases of hallux valgus, when a person so afflicted wears a pair of new shoes. Probably a small hæmorrhage takes place into the bursa which is sufficient to set up an inflammatory reaction.

**Acute infective bursitis** is always dependent on the introduction of micro-organisms into the wall or cavity of the bursa either by direct infection through a wound, or by spread from a neighbouring cellulitis or arthritis.

The recognition of these conditions is as a rule simple; the following points should be made out:—

1. The history of the onset of the condition.
2. The presence of an exciting cause.
3. Acute pain in the region of a normally placed bursa or a site where an adventitious bursa is likely to be found.
4. The presence of a swelling in such a situation, varying in size according to the amount of effusion into the bursa; fluctuation is obtained if an excess of fluid is present.
5. If in a subcutaneous situation the skin shows the ordinary signs of inflammation, which are especially well marked in the infective variety.
6. In the non-infective variety the fluid is clear and thus the sac will

be translucent. If pus or blood is present the swelling will be opaque on transillumination.

7. In the infective variety the surrounding tissues show much brawny œdema.

8. By aspiration of the bursa the withdrawal of serous or purulent fluid clinches the differential diagnosis.

**Chronic bursitis.**—This condition is most commonly the result of repeated trauma. The clinical signs are the same as those above mentioned, with the exception that there is usually no pain; the effusion, which is usually serous in character, persists for a long time; deposits of fibrin, which on account of their size and appearance are known as *melon-seed bodies*, sometimes form in the bursa; the presence of these bodies can sometimes be recognised clinically by a curious crackling sensation felt on palpation, and suggests that the condition is tuberculous in origin. Synovial protrusions may take place into the cavity of the bursa; fibrous strands may stretch across it from side to side; the walls of the bursa eventually become very thick if the condition is untreated, and the whole bursa may become converted into a mass of fibrous tissue (*chronic fibrous bursitis*). Acute exacerbations of inflammation are liable to occur, and if the skin over the surface becomes very much stretched owing to the effusion, infection or rupture may ensue; sometimes the bursæ rupture through the deep fascia producing a hernia of the bursal wall.

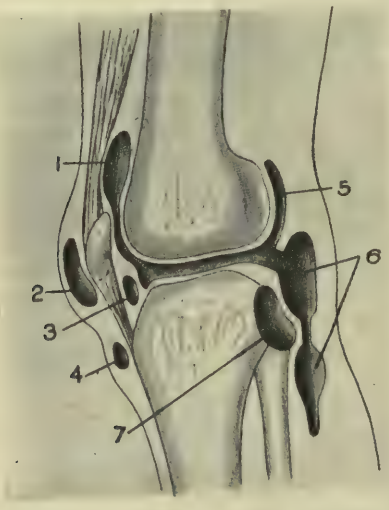



FIG. 90.—Bursæ and cysts about the knee. 1. Subcrureus bursa communicating with joint. 2. Prepatellar bursa. 3. Bursa beneath the ligamentum patellæ. 4. Bursa over the tubercle of the tibia. 5. Synovial cavity of knee-joint distended behind the condyles. 6. The same enlarging and spreading downwards into the calf (Morrant Baker's cyst). 7. Semimembranosus bursa, which frequently communicates with the joint.

The prepatellar bursa is affected in those whose occupation requires a lot of kneeling, *e.g.*, housemaids (hence the term *housemaid's knee*); similar conditions are seen in connection with the olecranon bursa (*student's or miner's elbow*), the ischial bursa (in weavers, coachmen, and boatmen, and known as *weaver's bottom*), and the bursa under the tendo Achillis in persons whose occupation necessitates a lot of walking. The bursa between the ligamentum patellæ and the tibial tubercle is often involved, and also the bursæ over the trochanters. Adventitious bursæ over a prominent exostosis are frequently seen.

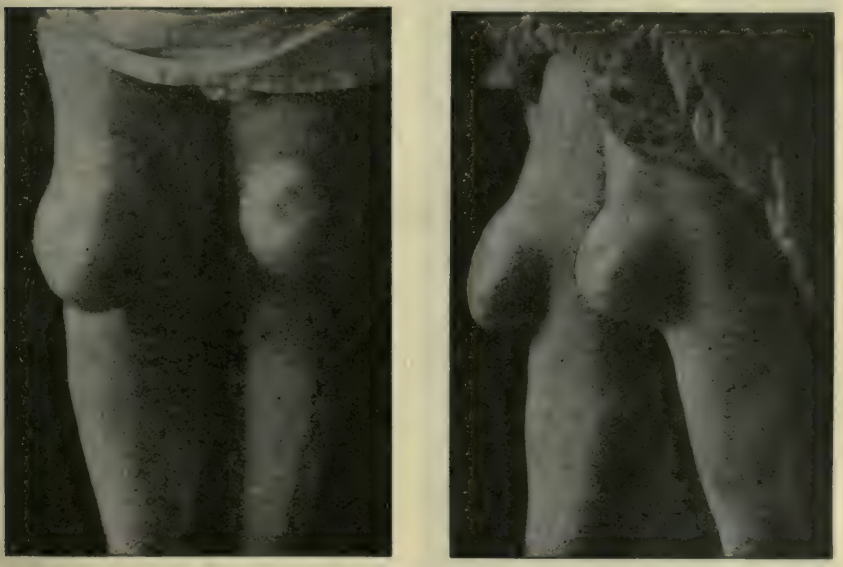
Special attention must be paid to the bursæ which communicate with joints, the inflammatory condition of the bursa being usually due to a primary affection of the joint, for example, osteoarthritis, rheumatoid arthritis, or tubercle. Examples are the psoas bursa and the deltoid bursa which frequently communicate with the joints. Care must be taken in examination to define the relation of a bursa to the neighbouring joint by demonstrating the possibility of passing the fluid from the bursa into the joint or *vice versa*; a disease of the joint must also be recognised.

The enlargement of normal bursæ must be distinguished from "*Baker's*

*cysts.*" These are cystic swellings derived from protrusions of synovial membrane through the capsule of a joint; Baker's original specimens were all connected with tuberculous joints. The diagnosis of tubercle may be made by the demonstration of tubercle bacilli in the fluid obtained by aspiration of the bursa; otherwise it is often difficult to distinguish the condition from other forms of chronic bursitis.

**Syphilis** in the tertiary stage may attack the walls of bursæ, producing gummata, which are often multiple and frequently occur in symmetrical positions. The ischial and prepatellar bursæ are the commonest situations for this condition. In the later stages gummata are liable to break down, forming typical syphilitic ulcers. A history of primary and secondary lesions, combined with a positive Wassermann reaction and ready response to treatment, confirms the diagnosis.

**Gouty tophi** sometimes form in bursæ and may reach a considerable size;



A. B.

FIG. 91.—Bilateral prepatellar bursæ. Photographed from two positions. (Kindly lent by Mr. G. P. Newbolt.)

the swelling is densely hard, and usually associated with the presence of other deposits in such situations as the pinna, the finger and great-toe joints; they tend to cause ulceration of the skin.

**Growths** are but rarely seen in bursæ. Sarcomata have been described in connexion with the prepatellar bursa; as a rule they are slow-growing. Endotheliomata are also described.

*Treatment of bursitis.*—The treatment of these conditions depends to a certain extent on the type of bursa involved.

The main principle in all cases is to remove the cause of the lesion. A change of occupation, the removal of pressure from bony prominences, the removal of exostoses, the treatment of joint affections, the use of anti-syphilitic remedies, etc., all demand attention.

*Acute non-infective bursitis.*—During the acute stages the limb must be put at rest, splinting even being adopted if necessary. Pain, which is the

most prominent symptom, must be relieved by the application of heat, the use of leeches, and, if necessary, aspiration to remove the effusion; the two latter methods are seldom required; sedative drugs should be administered. When the acute symptoms have abated, pressure should be applied and moderate use of the limb encouraged. If the effusion does not subside, aspiration may be practised before the pressure is applied.

*Acute infective bursitis.*—Infection usually takes place through the skin, which is frequently very thin over the surface of the bursa. The bursa should be incised and the pus let out; a drainage tube should be inserted for twenty-four hours and then the wound allowed to granulate up. It is not, as a rule, necessary to wash out the cavity with antiseptics. If the infection has spread from a neighbouring focus, this must be dealt with at the same time. Prompt treatment is very desirable in this condition in order to avoid a rupture into the tissues with the production of a cellulitis, which may become a serious condition.

FIG. 92.—Ischial bursa. (Westminster Hospital Museum.)

*Chronic bursitis.*—In dealing with non-infective bursitis the removal of the cause is of primary importance. If the effusion still persists, rest, aspiration, the application of counter-irritants, pressure, or the injection of irritant fluids into the sac can all be tried. Of the counter-irritants, Scott's dressing or a mixture of tincture and liniment of iodine, applied locally, is the most efficacious; cantharides blisters may also be tried. Puncture of the bursa with a tenotomy knife and scarification of its wall sometimes meets with success, but as a rule the most satisfactory method of dealing with the condition is by excising the bursa; this is often expedient, as tuberculous infection is sometimes responsible for the failure of the simpler methods of treatment. A bursa containing melon-seed bodies, or one which has become converted into a fibrous mass, usually requires excision. Many of these bursæ track for a considerable distance among the tissues, as in the case of the semi-membranosus bursa, which often extends well down the leg among the calf muscles; great care is required to ensure complete removal of the sac. Again, if it is in the region of a joint, injury to the joint capsule must be avoided by keeping the knife close to the wall of the bursa; if the bursa communicates with the joint, the capsule must be closed by ligature.

Bursitis of tuberculous origin, if apart from joint affection, is treated by excision.

Gummatous bursitis responds to antisyphilitic measures.

Bursitis associated with joint affections, whether they are tuberculous,

pyogenic, gonococcal, or osteoarthritic, requires to be dealt with by attention to the joint itself. If the joint responds to treatment, the bursitis usually resolves. If it does not, then the above lines of treatment should be adopted. If the joint affection demands surgical interference, as in excision of the knee-joint for tuberculous disease, great care must be taken to remove the infected bursæ at the same time.

Adventitious bursæ require treatment of the underlying cause. When an exostosis is removed the bursa should be taken with it; in the operation for hallux valgus the *bunion* is also dealt with.

Gouty tophi, on account of their size or because they are causing ulceration of the surface tissues, sometimes require excision.

Growths should be excised; the prognosis in cases of sarcomata and endotheliomata is fair.

## Affections of Muscles.

(N.B.—For "*The Electrical Reactions of Muscles*," in health and disease, see pp. 197 and 353.)

**Atrophy of muscle.**—The commonest cause of muscular atrophy is *disuse* of a limb. Disease of a joint around which the muscles are situated is another cause of atrophy. In certain forms of joint disease, *e.g.*, tuberculosis, the loss of muscular substance is greater than can be explained by mere disuse; this is attributed to local toxic action setting up an interstitial myositis which leads subsequently to atrophy. Muscles are often put out of action by the presence of a swelling underlying them, *e.g.*, a bony growth or abdominal distension. Long-continued resting of a limb leads to atrophy.

Atrophy as the result of *injury or disease of the central or peripheral nerve supply* of a muscle, as occurs in anterior poliomyelitis, is a more important cause from the point of view of end result. Here, in the early stages, the diminution in the bulk of the muscles is due to the shrinkage of individual muscle fibres and subsequent fatty degeneration, until eventually no contractile tissue remains. Sometimes the muscle sheath is found encasing a mass of fatty tissue only, or the muscle may be represented by a mere fibrous cord.

Clinically, the condition is most commonly seen in connexion with the muscles of the limbs, which by measurement will be found to be diminished in circumference; the tone of the muscle is lost, so that it feels flabby; loss of function, either partial or complete, will be demonstrable; the degree of destruction of the muscle can be ascertained by testing for the *reaction of degeneration*—that is to say, the retention of the power of contraction to the galvanic current, but not to the faradic current; moreover, the former property is more marked at anodic closure than at the kathodic. The appearance of this reaction in the early stages is suggestive of a graver prognosis than if it only takes place from the tenth to the fourteenth day; in the former case complete recovery is unlikely to occur, whereas in the latter recovery is probable.

In the advanced stages of atrophy the affected muscles will become stretched owing to the over-action of the opposing groups, which tend to remain permanently contracted and lead to deformities.

*Treatment.*—The obvious line of treatment is to remove the cause of the disuse or to deal with injuries to peripheral nerves. If complete repair cannot be obtained, the muscles should be so treated as to place them in a position to give the best functional result possible.

In a case seen in the early stages, especially one in which the primary lesion

is of nerve origin, the affected muscles should be placed in such a position that they cannot be overstretched by the opposing muscles; celluloid splints, or supports acting in such a way as to imitate the action of the muscles, should be used. Such splints should be removable so as to permit of the use of massage and electrical treatment. Both passive and active movements should be encouraged. When deformities have arisen, suitable surgical measures should be adopted to correct them, *e.g.*, tenotomies, tendon lengthening, or tendon transplantation.

**Volkmann's ischæmic contracture.**—This is a condition of contracture of muscles resulting from an interference with their blood supply. Over-tight application of splints or plaster bandages, greatly prolonged application of a tourniquet, or injuries to large blood-vessels are amongst the commonest causes.

The muscle fibres undergo rapid degeneration and atrophy; the nerves may be involved in a form of neuritis, and subsequently contracture of the muscle results. Pain may be a premonitory symptom, but is usually absent, hence the condition is often not recognised until the splints are removed. The extremities of the limbs are swollen, bluish in colour, and, the muscles being hard and contracted, attempted movement is painful. The muscles

Fig. 93.—Ischæmic paralysis of the forearm following a fracture into the elbow joint, showing scars resulting from splint sores.

also become paralysed and exhibit the reaction of degeneration. Permanent contracture is the common end result. The flexor muscles of the forearm and intrinsic muscles of the hand are most commonly involved.

A characteristic deformity of the hand is noted; the phalanges are flexed, the metacarpo-phalangeal articulations are extended, and the fingers can only be extended when the wrist is flexed. In the more severe cases the wrist may also be flexed.

*Treatment.*—The treatment should be as for muscular atrophy due to other causes. Operative measures may be called for and consist in either shortening the bones by partial excision or lengthening the affected tendons. The results, however, of these methods are not very satisfactory.

**Injuries to muscles.**—Muscles may be injured either by direct or by indirect violence. A blow, kick, or fall on a muscle may produce a tearing of fibres, varying in extent according to the nature of the injury, followed by an extravasation of blood; discoloration of the skin from the effused blood is seen at a later stage. A similar injury to a muscle is often associated with fracture of a bone, especially if the fracture is in the region of the origin or insertion of a muscle; bone cells often grow into the torn muscular fibres, later producing a bony mass (*traumatic myositis ossificans*).

Muscles may be torn whenever the skin is cut with a sharp instrument or during surgical operations, when the lesion is obvious on inspection. Pain at the site of the injury together with a temporary loss of function are the

most prominent symptoms. Indirect violence most often leads to *rupture* of a muscle. Such may be partial or complete, and may or may not involve the muscle sheath; sometimes the sheath only is torn, thus allowing the muscle fibres to protrude through the hole, a condition spoken of as a *muscular hernia*.

The rupture most commonly follows a sudden violent voluntary or involuntary contraction. A muscle weakened by predisposing causes, such as prolonged fevers or unusual exercises, is more often the site of injury than one in a normal condition.

Partial ruptures are often quite insignificant—*e.g.*, the spinal muscles are often torn as the result of over-straining; the gastrocnemii rupture during the carrying out of violent leg exercises, such as tennis (*tennis-calf*); the adductor muscles rupture during riding exercise. The more complete ruptures are of a serious character and take place most commonly at the junction of the muscle fibres with the tendon—*e.g.*, the tearing of the rectus femoris just above the patella in persons who involuntarily contract the muscle to save themselves from falling; the tearing of the rectus abdominis as the result of spasmodic contractions associated with tetanus. Continued strains on muscles, as in the reduction of dislocations, the lifting of heavy weights, or the rupture of the sterno-mastoid during the delivery of the after-coming head during child-birth, have similar results. Large quantities of blood are frequently extravasated into the surrounding tissues and temporarily fill up the gap in the torn muscle. Later, during the process of healing, this organises to form fibrous tissue with subsequent contracture, unless great care is taken to prevent it. It is very rare for new muscle fibres to form between the two ends of a torn muscle.

Sudden pain at the site of the lesion associated with inability to put the muscle into action is the most prominent symptom; often the patient is conscious of a sensation of tearing. In the minor forms of rupture no lesion can be discovered. In the more severe, however, with the limb at rest, a swelling is seen (two such swellings if the tear takes place in the centre of the muscle belly), which increases in size and retracts towards the site of origin of the muscle when the latter is put into action; on the distal side of the swelling a depression is found, often allowing the underlying structures to be felt. The swelling is movable from side to side, but not in the line of the muscular fibres. It becomes fixed when put into action. It is quite soft while at rest, but hard when contracted. In the gap fluctuation may often be obtained, if there is enough blood extravasated: later, this becomes clotted, and may remain permanently as a hard mass in the course of the muscle; more often, it disappears and is replaced by fibrous tissue, which may either contract, causing deformity, or stretch, leaving a weak limb.

*Muscular hernia.*—A hernia of a muscle results from a tear of the sheath, which allows the muscle fibres to protrude through the hole so formed. It is caused by a number of repeated violent muscular actions. The muscles of the abdominal walls, the adductors of the thigh and tibialis anticus, are most commonly affected. When the muscle is put into action the swelling gets smaller, and if the action is opposed it may completely disappear.

*Treatment.*—In the minor forms of injury the limb should be elevated for a few minutes and strapping applied. The patient should be encouraged to use the limb immediately despite the pain which is produced thereby; massage should also be employed.

If there is a large hæmatoma the limb should be put at rest in the position of relaxation, ice-bags or evaporating lotions being applied until the pain

and effusion have subsided; this should be followed by the treatment indicated above. If there is marked ecchymosis of the skin, hot applications are preferable.

In the case of a large rupture operative measures will usually be required, but fair results may be obtained by relaxing the muscle and applying strapping so as to approximate the torn ends.

If suture of the muscle is undertaken for the rupture, the involved portion should be exposed, the blood-clot cleaned out, the muscle edges freshened and the ends united. The process of healing takes about three weeks.

A hernia of muscle is treated by exposing the rent of the sheath, cutting off the protruding portion of muscle, and suturing the hole.

**Myositis.—Simple myositis.**—One form known as traumatic myositis results from minor injuries, in which hæmorrhage has occurred.

Other conditions coming under this heading are supposed to be of "rheumatic origin" and result from chills, causing stiffness and pain in certain muscles, especially those of the neck and back.

The *treatment* consists in relaxing the muscles and giving massage and movements both passive and active. If the pain is severe hot applications, belladonna plasters, with internal administration of salicylates, should be used.

**Infective myositis.**—Inflammations of muscles may be either Acute or Chronic.

**Acute infective myositis.**—This condition may be due to—(1) direct infection following a wound, *e.g.*, in a street accident or a bite of the tongue; (2) extension from a neighbouring focus, *e.g.*, from a joint—more often extension is along the inter-muscular planes; or (3) metastasis in pyæmic conditions, of which glanders is a good example. The micro-organisms responsible for such conditions are of the ordinary pyogenic types, causing suppurative lesions similar to those found in other parts of the body.

The *signs and symptoms* are those of acute inflammatory processes elsewhere, but exaggerated when the muscles are put into action.

*Treatment* is as for inflammatory processes in general.

**Chronic myositis.** — *Tuberculous myositis.* — Tuberculosis very rarely involves a muscle primarily, and usually the infection spreads from a lesion in a bone or lymphatic gland in its neighbourhood. Examples are to be found in cases of spinal caries involving the psoas muscle, and cervical adenitis spreading to the sterno-mastoid. Localised nodules of caseous material may be found, or more commonly an abscess. The diagnosis depends on the recognition of the primary lesion.

*Treatment* consists in the removal, if possible, of the muscle affected, but often palliative means only can be adopted.

*Syphilitic myositis.*—During the secondary stage muscular pains are frequently complained of.

About a year after infection a condition is sometimes seen which starts with pains in the muscles, especially at night-time, passing from a condition of stiffness to progressive atrophy and contracture, often of a severe character. The calf and neck muscles are most commonly affected.

Gummata are the commonest lesions due to the *spirochæta pallida*. Any muscle of the body may be involved, but those of the tongue and the sterno-mastoid may be especially mentioned. The lesion, which is usually single, commences as a firm, smooth, hard, painless, rounded localised swelling in the muscle. Laterally, where in contact with the sheath of the affected muscle, its margins are definite and rounded, but tend to fade away, above and below, into the normal muscular texture. The swelling subsequently

softens, and if superficially placed bursts on to the surface, giving rise to a characteristic gummatous ulcer; under treatment this heals with the formation of scar tissue.

The swelling is sometimes mistaken for a sarcoma, but the history and the result of treatment confirm the diagnosis.

*Treatment* consists in the giving of antisyphilitic remedies.

*Actinomycosis* involves muscles, but always secondarily to some other primary focus. The masseters, the intercostals, and the muscles of the abdominal walls are those most frequently affected. The characteristic induration of the muscles, with small suppurating foci discharging pus containing the characteristic granules, makes the diagnosis easy. This is confirmed by bacteriological investigations.

## Bone Formations in Muscles.

**Myositis ossificans.**—Myositis ossificans is a congenital condition usually seen in small boys and very rarely in females. It is a progressive lesion, thought to be due to some obscure inflammatory process, leading to a deposit of flattened bony masses in the fascial and aponeurotic coverings of the muscles; these are not connected with the periosteum of the bone, and are deposited quite irregularly. Deformities result. The muscles of the back are those most commonly affected; the condition may spread to other regions, but this is quite exceptional. The patient usually lives for ten to twelve years, and then dies of respiratory embarrassment and its complications. Irregular epiphyseal ossifications are often seen, and curiously enough the proximal phalanx of the thumb and great toe are often absent or ill-developed.

Progressive limitation of movement, or even absolute immobility, of the back muscles is observed.

There is no treatment which will prevent or cure the condition, although removal of the bony plaques will sometimes permit of essential movements.

**Traumatic myositis ossificans.**—An acute and chronic form of this condition are recognised. In the *acute* variety there is a history of a single injury leading to pain and swelling in the region of a muscle attachment. As the symptoms pass off, towards the end of the third to fourth week, there appears a bony mass recognised by radiography, and often of such a size as to cause disability of a joint, if the muscle affected is in its region. The brachialis anticus at its insertion into the ulna is commonly involved. It occurs in young persons. If suitably treated the bone is usually absorbed in about a year and the muscle returns to its normal condition.

*Treatment.*—Removal of the mass is contra-indicated in the early stages, as recurrence always follows. The limb should be put at rest until no more bone is deposited; massage and movements should then be commenced. If at the end of a year there is still disability, then removal should be advised.

In the *chronic* form the bony tissue is deposited slowly and results from repeated small injuries. The commoner sites are the ends of the adductors, seen in those accustomed to riding (hence the term "*rider's bone*"); the origin of the deltoid in soldiers (hence "*drill bone*"); the origin of the vastus externus. The patient does not usually complain of symptoms other than the appearance of a swelling.

*Treatment.*—Unless giving rise to symptoms it should be left alone; otherwise removal is indicated.

The pathology of these conditions is probably the same. As the result

of injury, the muscle fibres tear up with them a piece of periosteum and some of the attached bone cells. The latter are scattered amongst the blood-clot and muscular connective-tissue cells, and during the healing process cause ossification of the scar tissue. The masses may remain fixed to the bone or lie loose in the muscle.

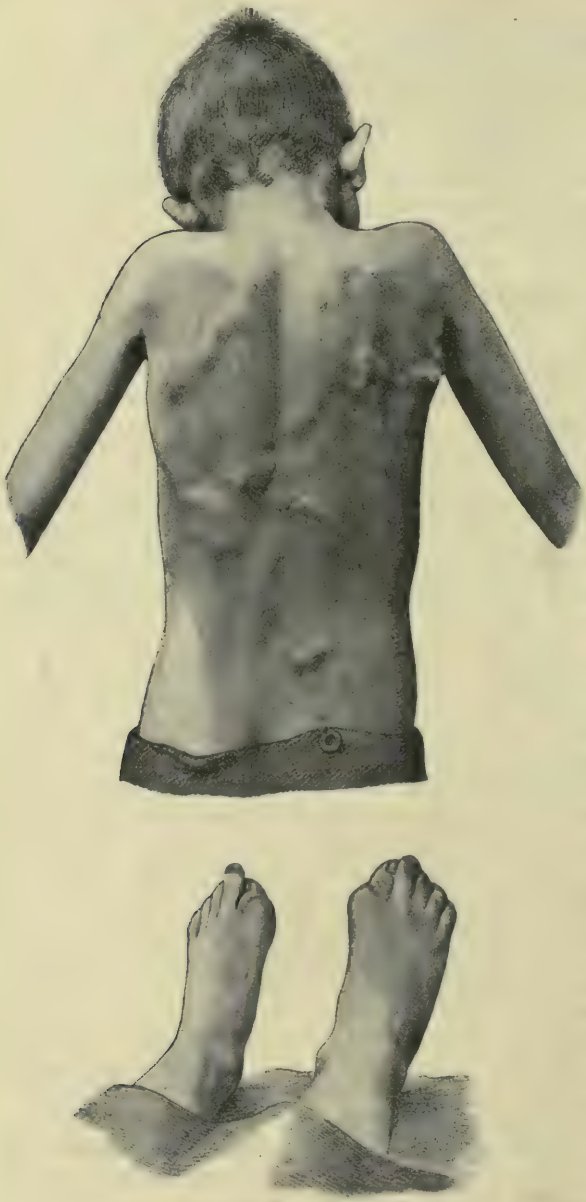


Fig. 94.—Myositis ossificans. (From T. Sympson's original paper in the Clinical Society's Transactions, vol. xix.)

**Tumours of muscles.**— Innocent tumours of muscles are rarely seen. Tumours composed of striped muscle, with the exception of certain congenital tumours occurring in the kidney (rhabdomyomata), are not met with. The innocent tumours are derived from the intramuscular connective tissues, and fibromata of the abdominal muscles, lipomata and angeiomata, seen in the tongue or sterno-mastoid, are the commonest.

Malignant tumours of primary origin are sarcomata. They are mostly slow-growing and of the nature of fibrosarcomata; when removed they tend to recur, hence the term "recurrent fibroids." When seen in the muscles of the anterior abdominal wall they are known as *desmoids;* they frequently attain a considerable size. Similar growths are seen amongst the muscles of the thigh, and in the sterno-mastoid.

Carcinomata are always secondary in origin.

Hydatid cysts are sometimes found in muscles.

A tumour of muscle is recognised by the fact that it lies in the situation of a muscle, that it will move from side to side but not in the line of the muscular fibres, and that when the muscle contracts the tumour becomes fixed and less obvious. It must be distinguished from a "phantom tumour," especially if situated in the region of the rectus abdominis. Such will appear in hysterical women, and frequently over the site of intra-abdominal pain. The tumour disappears when the patient is under an anæsthetic.

*Treatment.*—Innocent tumours rarely call for treatment. Malignant tumours, if attached to the muscular sheath only, may be removed locally, but where possible, as in a muscle of a limb, the whole muscle with its sheath should be excised. Amputation of the affected limb may be necessary.

# Section V.

## SURGERY OF THE BLOOD-VESSELS.

### Hæmorrhage.

By hæmorrhage is meant the loss of blood which occurs when the wall of a blood-vessel is penetrated or cut across. The blood which flows out may escape through the skin or mucous membrane, and the hæmorrhage is then termed *external* or apparent, or the blood may pass into one of the body cavities, such as the peritoneum, or into the pregnant uterus, or merely into the tissues themselves, when it will be hidden, and the hæmorrhage is then termed *internal* or concealed.

A large quantity of blood may be lost rapidly at one given time, or smaller quantities may escape repeatedly.

When the loss is considerable and rapid, it will be accompanied by marked *signs*, which will be evident whether the blood is seen or hidden.

The surface of the body, both skin and mucous membrane, will become pale because there is less blood circulating in the superficial blood-vessels, and cold because there is a want of warm blood in the part. As a consequence the superficial and deep temperature of the body is lowered.

The pulse becomes small because the volume of blood in the vessel is diminished, rapid because the heart is endeavouring to supply the deficiency of blood by a quicker flow, and weak because the arterial pressure is greatly lowered.

The respirations become quickened because there is a need for a quicker interchange of gases in the lungs owing to the lessened bulk of blood available for oxygenation, and later the respirations may become sighing or gasping.

There is often great restlessness, and considerable thirst due to abstraction of fluid from the tissues to make up the loss.

The functions of the special senses may be interfered with, so that loss of vision, singing in the ears, and loss of consciousness may result.

As a patient recovers from a severe loss of blood the pulse is often said to be "hæmorrhagic" in character—namely, it becomes large, dichrotic, and easily compressible. The blood itself shows a diminution in the number of red cells, and in hæmoglobin, but an increase in the number of leucocytes and in the proportion of serum.

Repeated small losses of blood may be much more readily borne than a rapid and fairly large escape. But these small losses may give rise to marked anæmia, some œdema of the lower eyelids and of the feet, liability to attacks of fainting, and the characteristic "hæmorrhagic" pulse.

The loss of a small quantity of blood is naturally better borne than the loss of a larger quantity; the rapid loss of blood is less well borne than a slow or intermittent loss; hæmorrhage is less well borne by the male, the young, and the aged than by the female and the middle-aged.

Any previously existing anæmia, cachexia, or sepsis renders a severe loss of blood a most dangerous condition.

Death may occur from loss of blood, and is primarily due to the fact that the vital centres in the medulla are deprived of the fluid which is essential for their function. This deprivation is brought about mainly from the great diminution in the arterial blood pressure and the weakness of the heart, so that blood cannot reach the distant parts. The recognition of these facts has an important bearing upon the treatment of hæmorrhage.

Recovery from loss of blood takes place first of all by the arrest of the bleeding, and secondarily by the restoration of the proper amount and composition of the blood in the vessels.

**The arrest of hæmorrhage.**—The arrest of hæmorrhage necessarily consists of two stages—temporary and permanent,—and unless the two follow one another death will occur.

**Temporary arrest of hæmorrhage** is both natural and artificial; the natural method of arrest may be sufficient or it may need to be supplemented by the surgeon to be effectual.

**Nature's methods for the temporary arrest of hæmorrhage.**—These are two—the general and the local. When there has been a considerable loss of blood the patient as a rule faints and falls to the ground and remains lying quiet; this in itself tends to prevent further loss of blood. The force of the heart's beat is much lessened, and this tends to prevent the dislodgment of the internal and external clot, to be mentioned later. The altered composition of the blood renders it more prone to coagulation and this tends to arrest the bleeding. These are the general means which Nature adopts to stop temporarily the flow of blood from a vessel.

The local means are as follows: retraction and contraction of the cut end of the vessel, if it is an artery and has been completely divided. The contraction renders the orifice of the vessel smaller, while the retraction within its sheath allows of the more ready deposition of clot, causes in-turning of the inner and middle coats of the wall of the vessel, whereby the lumen is diminished and an irregular surface presented to the blood-stream. There is then the formation of a thrombus or clot within the vessel, the internal clot, which reaches as far as the first fair-sized collateral branch, and a clot outside the cut wall of the vessel, the external clot, which is the chief local factor in the temporary arrest. Sometimes that part of the clot which lies actually in the lips of the orifice of the vessel is termed the central clot.

As the blood, which is flowing in a diminished stream every minute, passes over the roughened surface of the curled-in inner coat of the vessel and of the tissues outside, clotting readily occurs, the aperture is lessened and finally occluded, and the flow of blood ceases.

If the vessel is torn or lacerated, the roughened surface becomes thereby greater and the coagulation is made more easy. On the other hand, a clean-cut wound in the vessel tends to prolong the escape of blood owing to the longer time taken before an efficient clot is formed. So also, when a vessel is only partially divided, retraction and contraction is to a great extent prevented, and hæmorrhage is likely to continue and to be severe.

The temporary arrest brought about by Nature is often sufficient to control bleeding from an artery even as large as the radial. This temporary arrest may be defeated by too early administration of stimulants, which, by causing a stronger action of the heart, may induce displacement of clot.

**The surgeon's methods for the temporary arrest of hæmorrhage.** The surgeon can only arrest hæmorrhage temporarily; it requires Nature to stop

bleeding permanently. But the surgeon may do a great deal to help Nature in bringing about the desired permanent cessation.

The methods which the surgeon employs are conveniently classified as follows :—

1. Pressure.
2. Ligature.
3. Torsion.
4. Heat and cold.
5. Styptics.
6. Drugs.

1. **Pressure.**—This is one of the most effectual methods for the temporary arrest of hæmorrhage. It may be applied—

(*a*) *Directly on the vessel at the site of the wound. Digital pressure.*—It is remarkable what a small degree of pressure, applied with the finger over the exact bleeding point, will arrest the loss of blood. Many a life may be saved by a knowledge of this simple fact. *Instrumental pressure.*—By pressure forceps or clamps. Here the forceps may be put on as a preliminary to ligature, or may by themselves in a few minutes adequately occlude the open mouth of the bleeding vessel. In other cases it may be necessary to leave the forceps applied to the vessel for forty-eight hours to allow Nature's method of permanent arrest to be sufficiently advanced to exclude danger of recurrent hæmorrhage. *By gauze.*—This acts not only by the pressure exerted, but also by the rough surface of its meshes causing a more rapid coagulation, and it is a very efficient means of dealing with capillary oozing in deep cavities. The gauze is left applied for about two days. It takes the place of the cobweb or the matico leaf of the older surgeons.

(*b*) *To the vessel on the proximal side of the wound* (if an artery). Here again the pressure may be applied with the finger or by means of instruments. Digital pressure assumes that the anatomy of the vessel is well known, for the finger must be placed directly over the vessel and used to press the vessel against resisting tissues deep to it. The amount of pressure which is needed to control the bleeding is much less, provided it is rightly applied, than is usually imagined ; this fact is of importance because but little muscular force is requisite and the operator can continue the pressure for a long time with little fatigue. Instrumental pressure is generally applied by means of one of the many varieties of tourniquet. The simplest is undoubtedly an elastic cord made of indiarubber with a hook firmly attached to one end. The limb being protected at the site of the application of the tourniquet by several layers of gauze so that the skin may not be injured, the elastic cord, whilst stretched, is brought several times round the limb, and finally the part near its end is slipped under the hook and so held in position.

If the tourniquet is not applied sufficiently tightly it may defeat its object by restricting the return of blood through the veins but allowing its entrance through the arteries.

This form of temporary arrest of hæmorrhage is particularly useful during the amputation of a limb.

2. **Ligature.**—By ligaturing is meant the throwing of a loop of silk or other material around the vessel and tying the same with a reef-knot. The materials which are in common use for ligatures are—silk, catgut, sewing cotton, and kangaroo-tail tendon. Many other materials have from time to time been advocated, such as ox aorta, but they have not held the field so well as those just mentioned.

Of the substances used for ligatures none have all the advantages which

silk possesses. Twisted silk and floss silk are the two varieties of this material generally employed, the former for small vessels and the latter for those of large calibre.

When a vessel, especially an artery, has to be tied it is usually picked up, if possible free of surrounding tissues, by a pair of pressure forceps, and the ligature material is thrown around these and so down on to the vessel itself; after the first half of the knot has been tied the forceps is removed and the second half of the knot made. The ligature should be tied sufficiently tightly to occlude the lumen of the artery, but it is not necessary to rupture the internal and middle coats. It is important that there should be a sufficient length of artery between the site of the ligature and the open end so as to minimise the possibility of the force of the heart's action pushing the ligature off the vessel. For the same reason a reef-knot is desirable, for a "granny" knot is apt to slip. In some positions, particularly where it is difficult to get down on to the vessel which is being tied, it is well to use a "surgeon's" knot, the first half of which is less likely to loosen while the second half is being tied than is the case with an ordinary reef-knot.

3. **Torsion.**—By torsion is meant the twisting of the vessel in such a manner that its coats remain wound round and the lumen thus obliterated.

There are two methods of applying torsion. The first is that which is called "direct," and consists in picking up the vessel in a pair of pressure forceps and then slowly twisting the forceps round with the handles describing the base of a cone, of which the end of the vessel is the apex. This twisting must be carried out for at least five turns. It is efficient for the occlusion of veins of medium size and for small arteries. The second method is to seize the artery transversely to its long axis by a pair of forceps and then to seize its open mouth with another pair and slowly to rotate the portion of the vessel which lies between the two pairs of forceps. This method is applicable to the larger arteries, but veins are generally too thin-walled to allow of its being used safely. Torsion is never a certain method of closing the open mouth of a vessel, but it is convenient and rapid for small vessels and in those instances where suitable ligature material is not at hand. But in these days of asepsis there is no advantage in torsion over ligature for the large arteries.

4. **Heat and cold.**—The oldest means of arresting hæmorrhage was the use of the actual cautery at a dull red heat, or the application of molten metal. The cautery is merely one of the methods for the arrest of bleeding by heat, and in certain cases it is extremely useful, as when there is surface oozing, or hæmorrhage from a wound which is already septic, for it not only arrests the flow of blood, but it also acts as an antiseptic. Before the cautery is applied the surface should be dried. Its use, however, has one disadvantage, and that is, when the slough which is formed separates, there is some tendency for secondary hæmorrhage to occur.

Hot water at a temperature of from 120° F. to 150° F. (= 50° C. to 65° C.) causes active contraction of small blood-vessels and is an efficient means of arresting capillary bleeding, especially in deep cavities. So, too, the application of ice or ice-cold water produces a marked contraction of the walls of the small vessels, and is useful especially in bleeding from mucous surfaces such as those of the mouth, pharynx, and stomach. The mere exposure of the surface of a wound to the colder atmosphere may in itself be sufficient to arrest much of the bleeding from small vessels.

5. **Styptics.**—Styptics are chemical substances which tend to bring about coagulation of blood and so the arrest of bleeding But while acting thus

they are apt to cause considerable damage to the soft parts around the vessel, and are therefore only used at the present day when other means are not available. Among styptics may be mentioned the perchloride of iron, a 1—20 solution of carbolic acid, alum, and tannic acid.

6. **Drugs.**—There are several drugs which are known to have the property of powerfully contracting blood-vessels. Of these an extract of the suprarenal or of the pituitary body is the most efficacious. In the strength of 1—1,000, adrenalin chloride solution will, when applied to a surface from which free oozing has been taking place, cause almost immediate blanching of the part by the contraction of the muscular tissue in the walls of the vessels. Ergot when administered internally acts upon the muscular tissue of the wall of the uterus and, causing contraction, presses upon the open venous channels and brings about cessation of post-partum hæmorrhage. Calcium chloride given previous to an operation is said to diminish the amount of loss of blood, acting, therefore, as a prophylactic.

**The permanent arrest of hæmorrhage.**—Nature alone can permanently arrest hæmorrhage, for all that the surgeon does is merely to stop bleeding temporarily in order to give the tissues time to heal. Briefly the process is as follows:—The clot within and without the vessel is after a few days permeated by leucocytes, derived from the *vasa vasorum* which have become dilated on account of the injury to the vessel wall, and also by fibroblasts derived from invading plasma cells. The red discs caught in the meshes of the clot disintegrate and their débris is removed by the action of the leucocytes. Fissures appear in the clot, to become lined by the growing endothelium, and thus to take on the function of new blood-vessels permeating the clot. These capillaries eventually communicate both with the vasa vasorum and with the lumen of the damaged blood-vessels on the proximal side of the internal clot. The mass of vascularised granulation tissue thus formed gradually becomes converted into fibrous tissue of a cicatricial nature, and what was originally the clot—external and internal—is now an integral part of the vessel wall. In this way the whole of the wound in the artery or vein is firmly sealed off and hæmorrhage permanently arrested.

**Treatment of the effects produced by hæmorrhage.**—In treating the effects of loss of blood, it must be remembered that to overcome the syncope resulting it is necessary to increase the force with which the heart muscle contracts. Hence it is imperative that the actual aperture through which the blood has been flowing should be temporarily but effectively occluded. Then there will be no chance of the increased force of the heart's action causing a fresh loss of blood and possible death.

General measures for restoration consist of rest, both local and general. Thus the patient should be kept lying down and persuaded not to throw the limbs about. The head should be at a lower level than the rest of the body, so that the blood which still remains within the vessels may reach the vital centres in the medulla the more readily.

Warmth is of prime importance; hence the patient should be wrapped in blankets and hot bottles placed near, but not in contact with, his skin. He should be given hot fluids by the mouth, coffee, tea, and milk being the best. The heat itself is beneficial, and the fluid, passing into the stomach, may be readily absorbed, and the blood-pressure thereby raised. Brandy or other alcoholic preparations cause some stimulation by their effect upon the mucous membrane of the pharynx and stomach, but, if absorbed, the alcohol has a harmful result by depressing the action of the cardiac muscle. Further, alcohol given by the bystander before the arrival of a

surgeon may seriously compromise the after-treatment by adding a further depression to that already in existence.

The symptoms of shock are in a great measure due to the fall of blood pressure resulting from the loss of fluid from the vascular system, and the sooner this pressure is restored, always provided that precautions are taken to prevent a further loss of blood, the quicker will be the recovery of the patient. The most valuable remedies at our disposal are the infusion of saline or gum solution and the transfusion of blood (see *Treatment of Shock*, p. 172).

Bandaging the raised limbs is another method of increasing blood pressure.

## Internal Hæmorrhage.

When bleeding occurs from a vessel and the blood appears externally, the source is usually evident and the treatment of the hæmorrhage is comparatively easy, but when the blood is lost into a cavity of the body, such as the peritoneum, matters are much more difficult.

There may have been a definite injury, as a wound of the liver complicating fracture of the lower right ribs, or the case may be one of ruptured ectopic gestation. The rapid loss of blood will bring about all the usual signs of anæmia of the brain, faintness, giddiness, nausea, loss of function of special senses, and a weak, small, rapid pulse. In some cases it is very difficult to determine whether the condition of the patient is due to loss of blood from a vessel into a body cavity, or whether it is simply a condition of shock, in which there is often a dilatation of the veins of the abdomen and a collection of blood in them. This difficulty is peculiarly liable to be present after so-called "buffer" accidents. There are two points which may help; they are the "air-hunger" and the restlessness of severe loss of blood, neither symptom being present in cases of shock alone.

In the treatment of internal hæmorrhage it is essential that no stimulant should be given and no transfusion practised until the hæmorrhage has been arrested by the surgeon or has ceased spontaneously. The patient should be kept as quiet as possible; morphia should be administered hypodermically; the head should be kept low, and in some cases of severe hæmorrhage the limbs should be bandaged.

Hæmorrhage into the thoracic cavity has become more amenable to direct surgical treatment as a result of experience gained in the recent war. The subject is referred to in the section devoted to the *Surgery of the Chest* (see p. 774).

Hæmorrhage into the abdominal cavity from a ruptured spleen or liver or ruptured ectopic gestation is quite amenable to arrest by surgical means. A torn liver may be sutured, a damaged spleen excised, and a ruptured Fallopian tube removed after ligature.

When the bleeding has been controlled it is necessary to combat the bloodless condition of the patient. The chief danger is due to the lessened amount of liquid within the blood-vessels and to the shortage of blood elements. Both can be remedied by the transfusion of blood.

## The Classification of Hæmorrhage.

Bleeding from a blood-vessel can be classified according to the type of vessel from which the blood issues, or according to the period at which the bleeding takes place after the wound of the vessel.

From the kind of blood-vessel damaged, bleeding may be arterial, capillary, and venous.

*Arterial hæmorrhage* is the bleeding which occurs from a wound of an artery,

and it is characterised by spurting, synchronous with the beat of the heart, by the red colour of the issuing blood, and by the comparatively large quantity lost in a given time.

When a very large artery is cut death may ensue almost immediately from the profuse loss of blood; when a medium-sized artery is divided the loss is not so great, and if prompt measures, even if only temporary and crude, are taken to arrest the flow the life of the patient will be saved; while a small artery severed may cease to bleed of itself in the manner which has been already described.

*Capillary hæmorrhage* is the oozing which occurs from capillaries. The amount of blood lost is not great, unless the oozing goes on for a considerable length of time, or is often repeated. In hæmophilia, capillary hæmorrhage may lead to a fatal termination.

*Venous bleeding* is that which occurs from a wound of a vein, and is characterised by the steady stream in which the blood issues, by its dark colour, and by the fact that a great quantity is not lost unless a large vein is opened or the part from which the blood is pouring is a dependent one.

A vein as a rule only bleeds from the distal end—that is, the one farther away from the heart—when it is cut through. But when a varicose vein is punctured or opened by ulceration, the bleeding may be very severe and may come chiefly from the proximal end, owing to the fact that the valves are incompetent and the blood pours down when the limb is dependent.

Hæmorrhage may also be classified from reference to the time at which it occurs after the wound of a vessel, and more particularly of an artery.

*Primary hæmorrhage* is that which occurs immediately upon the wound of a vessel. *Reactionary hæmorrhage* is that which comes on during the period of reaction—that is, during the time when the heart is beating more strongly and the patient is recovering from the effects of the loss of a considerable quantity of blood, or the shock of a severe operation. Reactionary is sometimes also called *intermediate* hæmorrhage. It has been said only to occur within twenty-four hours of the injury to the vessel, but any such arbitrary fixture of time is not scientific. Reactionary hæmorrhage is due to the stronger action of the heart causing the displacement of external or of internal clot, the forcing off of a ligature from the proximal end of a tied artery, or the untwisting of a vessel which has had torsion applied to it. Sometimes the bleeding is from the distal end of an artery, the proximal end only having been secured. It will thus be seen that reactionary hæmorrhage is due to the failure of Nature's or the surgeon's methods of temporary arrest of bleeding.

*Secondary hæmorrhage* is due to the failure of Nature's methods of permanent arrest of bleeding. Here again an arbitrary time is sometimes fixed, it being said that secondary hæmorrhage is the bleeding which occurs after twenty-four hours from the time of injury up to the complete healing of the wound, and especially between the seventh and the tenth days. Both these circumstances —the failure of permanent arrest and the time of onset—suggest the cause, viz., sepsis, with its serious results upon the vessels in the wound.

Fortunately, owing to the much more satisfactory treatment of wounds at the present day, sepsis is much less common, and therefore secondary hæmorrhage is but seldom seen. A typical example of this variety of bleeding is that which occurs in the septic stump wound. At the time of the amputation pyogenic organisms remain within or are introduced into the wound. For several days afterwards the parts appear to be progressing satisfactorily. Then the patient's temperature begins to rise, and he complains of pain in the stump, which becomes hot and swollen, and soon it is

evident that there is pus between the flaps. On the fifth day this is evacuated, the drainage having been delayed and the ends of the arteries bathed in pus for as long as forty-eight hours. As a result of this the arterial wall has become much softened, or even some actual ulceration has occurred. On the seventh day a small erosion of the wall of the vessel occurs, and a little blood escapes into the wound and stains the dressings. Nothing much is thought of this, but the next day a similar discharge takes place, and the amount of blood is distinctly greater. On the ninth day, without further warning, a sudden gush of bright arterial blood happens, and continues so profusely that the patient succumbs in a few minutes.

From this it will readily be seen that secondary arterial hæmorrhage is a very serious matter, and that its treatment is preventive and actual.

The preventive treatment resolves itself into two parts—the prevention of sepsis in the wound and the cleansing of the wound if sepsis is already present. The actual treatment of the bleeding has to be commenced at the very first warning, that is when the discharge from the wound is blood-stained. Besides the careful cleansing of the wound, pressure must be applied to the vessels in the wound. This may be done in one of two ways: either by the insertion of antiseptic gauze into the wound and down to the site of the leaking vessel, or by the application of dressings and bandages to the surface of the flaps. In addition to this, it is essential that a tourniquet should be ready to be adjusted in case these measures fail to arrest the loss of blood. The nurse or other attendant of the patient must be informed of the danger of a sudden and fatal gush, unless very prompt action is taken to deal with it. If the bleeding has recurred, it is best to open up the wound freely and to secure the artery at some distance from the spot where it is septic and eroded. Sometimes the application of the cautery at a dull red heat is useful, for not only does it help to stop the bleeding, but it aids in rendering the part less septic by destruction of the organisms.

Under the following conditions it is not only justifiable but imperative that the main artery of the limb should be cut down upon some distance on the proximal side of the bleeding point in the hope that this drastic measure will arrest the hæmorrhage—viz., where the simple methods advised above have failed, where it is definitely known that the bleeding is from the main vessel or from a branch very close to the main trunk, or where the loss of blood is from an artery close up to the highest part of the limb, as for instance after amputation at the shoulder-joint, when the only hope for the patient is to ligature the subclavian artery.

Where hæmorrhage of this secondary character has occurred from an artery in its continuity, amputation well on the proximal side of the septic area is urgently called for. It is useless in such a case to ligature the main vessel on the proximal side, for gangrene of the distal portion of the limb is almost certain to follow, and the condition of the patient will be far worse than if a primary amputation is done.

If secondary hæmorrhage occurs from a wound other than one in a limb the outlook is most grave, and, failing ligature of the bleeding point, the only other method of treatment is careful plugging of the wound with gauze impregnated with an antiseptic styptic, such as iodine.

## Hæmophilia.

*Hæmophilia* is a condition in which bleeding is prone to occur spontaneously or on the slightest provocation, and is very difficult to arrest. The origin is unknown, but the condition is to some extent hereditary, in that it

often occurs in members of the same family, and nearly always in the males, although it is almost invariably transmitted through the female line. The pathology of the disease is unknown. The time the blood takes to clot is prolonged from five to fifteen or thirty minutes. The bleeding may be started by the most trifling injury, such as a mere scratch of the finger, the extraction of a tooth, or a bite of the lip or tongue. Or it may occur spontaneously, when it is sometimes preceded by flushings of the face and throbbing of the arteries, and then commonly takes the form of epistaxis, or of extravasations beneath the skin, or of bleeding from the gums or intestines, or of effusion into a joint (see *Diseases of Joints*). When the result of a traumatism, the blood, except a large artery is wounded, oozes from the injured surface in a steady, continuous, and uncontrollable stream. The bleeding may last for weeks and then cease spontaneously, leaving the patient in an anæmic condition, from which, however, he may speedily recover; or it may terminate fatally by epistaxis, melæna, or cerebral hæmorrhage. Successive attacks are common at varying intervals, and to one of these the patient generally succumbs. Should, however, he survive the period of puberty, there is some chance of the tendency to bleed decreasing with advancing years, but it is a bar to all operations except those of urgency. The *treatment* consists in placing the patient at perfect rest in the recumbent position, in applying firmly a graduated compress or tampon of gauze, and in elevating the part when the bleeding comes from a limb. Internally chloride of calcium may be given in doses of ʒi every hour or two by the mouth, or in double doses in enemata until the bleeding is checked, then reducing to three times a day—an additional guide is the reduction of the coagulation time estimated by Wright's method. It has been suggested that transfusion of blood may be useful.

## Injuries of Arteries.

An artery may be injured in a wound which traverses the skin, or it may be injured subcutaneously. The damage to the arterial wall varies from a mere bruise to complete severance of the vessel.

When the wall of an artery is slightly bruised in the depths of a wound reparative inflammation takes place and, unless sepsis occurs, the bruised part recovers; but if the bruising is severe a weak spot may result and subsequent dilatation occur, or if sepsis supervenes ulceration with secondary hæmorrhage may follow.

When an artery is bruised subcutaneously, as for instance when a limb is run over or caught between buffers, if the injury is slight the vessel wall returns to the normal, but if the lesion is severe it is quite likely a weak spot may remain permanently and an aneurysm develop later on.

Wounds of arteries may be classified thus:—

(*a*) Non-penetrating.
(*b*) Penetrating.

*Non-penetrating* wounds may divide both the external and middle coats, leaving the internal untouched. In this type of woundpressure the of the blood within the vessel tends to protrude the intima, giving rise to one variety of traumatic aneurysm—a rare one—in which the sac wall consists solely of the internal coat of the arterial wall. If it is diagnosed that a large artery has been injured in the above manner, it is well to ligature the vessel on the proximal and distal side of the damage and divide the artery between the two ligatures. If this is not done, the patient should be warned that an aneurysm may follow.

*Penetrating* wounds of arteries vary from a small puncture, which may not allow the escape of more than quite a small quantity of blood, up to a complete severance of the vessel, which, if it is caused by a clean incised wound, is associated with profuse primary arterial hæmorrhage. On the other hand, if an artery—and even one of good size—is torn across, the bleeding is often not great, owing to the fact that the tearing through of the vessel wall allows the internal, and to some extent the middle coat, to curl up within the lumen of the artery, so helping to block the aperture.

Arteries may be incised transversely, obliquely, or longitudinally. A transverse wound which does not involve more than a part of the circumference of the artery is apt to bleed profusely. This is due to the fact that the longitudinal muscular fibres retract and cause the wound to become an oval gaping aperture. An oblique wound may gape somewhat, but not nearly to the same extent as a transverse one, while a longitudinal wound may gape very little and consequently less blood in proportion is lost.

A wound of an artery, whether subcutaneous or open, may lead to a number of different results, among which may be mentioned great loss of blood, thrombosis and gangrene, aneurysm, and secondary hæmorrhage.

The actual *treatment* to be adopted for a wound of an artery depends largely upon the nature of the wound and its effects. The first step is to arrest hæmorrhage. This can be temporarily accomplished by the pressure of a finger on the actual spot where the blood is issuing. The patient can sometimes be instructed to maintain this pressure with one of his own fingers while preparations are being made to deal with the wounded vessel itself. Occasionally in a limb, pressure on the main artery on the proximal (heart) side of the wound is more effective in the stopping of the bleeding. This pressure can be obtained either digitally by the fingers of the surgeon or a skilled assistant, or by the application of a tourniquet.

When the temporary cessation of the loss of blood has been secured the wounded vessel must be dealt with. The simplest procedure is to ligature the artery both on the proximal and the distal side of the wound in the vessel wall and to divide the vessel completely between the two ligatures. If the artery has been already divided both ends should be secured.

It will at once be seen that this method of dealing with a wounded artery implies that the circulation through the vessel is stopped, and if a main artery is thus occluded there is danger of gangrene.

The ideal method of treating a wounded artery is to repair the wound and leave the lumen of the vessel patent. Under favourable circumstances this ideal treatment can be carried out.

If the wound of the vessel is a clean cut and is such as to not divide it, an attempt may be made to suture the wound, taking care not to pass the stitches into the lumen of the vessel.

If the wound has cut the artery across, it is sometimes possible to suture the divided ends so as to restore the continuity of the vessel and maintain the patency of the lumen.

## Diseases of Arteries.

Arteries, like the other tissues of the body, are liable to disease, both of an inflammatory and degenerative character.

**Arteritis,** or the inflammation of an artery, may be acute or chronic.

**Acute arteritis** may be simple or septic. *Simple acute arteritis* occurs when an artery is wounded or contused aseptically and is the process whereby the repair of the vessel takes place. Within a few hours there is proliferation

of the cells of the tunica intima, and the blood coagulates opposite the damaged area. Cells then migrate into the adherent clot and, gradually permeating its substance, convert it into a mass of granulation tissue. This subsequently becomes fibrous tissue, so that the vessel is soundly healed.

*Septic or acute infective arteritis* arises from the spread of infection from a septic wound to the walls of an artery, or from a septic embolus lodged within an artery.

The termination of such septic inflammation is usually secondary hæmorrhage, or the softening of the wall of the vessel and the consequent formation of an aneurysm.

Fig. 95.—Primary calcification of arteries. (St. Bartholomew's Hospital Museum.)

**Chronic arteritis** may be simple or infective, and the infective types are the tuberculous and the syphilitic.

**Chronic simple arteritis** is also termed arteriosclerosis or atheroma. It is a condition which tends to occur in some degree in all persons over middle age, but it is most marked in those who have been the subjects of alcoholism, chronic nephritis, lead-poisoning, diabetes, or syphilis. Increased arterial tension also predisposes to the condition, and so do the toxins of enteric fever and rheumatism.

As the disease advances it will be found that the muscular coats of the artery degenerate, with compensatory thickening of the inner and outer coats: hence the hard, thickened arteries which can be so easily felt.

Arterio-sclerosis may lead to gangrene, aneurysm, or the lesser evils of loss of power and cramp in the lower extremities.

**Chronic tuberculous arteritis** is seen chiefly in the lungs, and the gradual destruction of the vessel wall is the cause of the sudden profuse and not infrequently fatal hæmoptysis.

**Chronic syphilitic arteritis** is of a type in which the lumen of the vessel becomes gradually obliterated by a proliferation of the cells of the inner coat. On this account the disease is termed endarteritis obliterans. The other coats also become thickened and fibrosed, and consequently all the softness of the vessel is lost. The lesion when occurring in the lower extremity may lead to gangrene.

**Primary calcareous degeneration.**—The medium-sized arteries of elderly people are apt to be the site of a degeneration which affects the middle coat, in which the circular muscular fibres are transformed into rings of earthy material due to the deposits of calcareous salts. The condition is practically always seen in the arteries of the limbs, and particularly those of the lower extremities. As a consequence of this degeneration the arteries become very greatly hardened and can frequently be felt exceedingly easily through the skin. The condition necessarily produces a loss of the natural elasticity of the vessels and arterial tone. This implies a deficient circulation in the peripheral parts of the limb, frequently associated with cramp and sensations of coldness or numbness and at times severe tingling. A skiagram may show the calcified vessels very beautifully (see Plate 18).

The lesion may lead to senile gangrene, fracture and rupture from external violence, and secondary hæmorrhage after ligature.

There is no known treatment of the condition, but care should be taken that the affected limb is protected from even slight injury, so that gangrene and rupture may be avoided.

This primary calcareous circular degeneration is to be differentiated from the **secondary** localised, plate-like deposits of calcareous salts in large atheromatous patches in the larger arteries, particularly the thoracic aorta.

## Aneurysm.

An aneurysm is a tumour, the cavity of which communicates with the lumen of an artery and contains blood.

*Varieties of aneurysms.*—Aneurysms may be classified according to whether they are due to some arterial disease or to traumatism. The former are called *pathological*, sometimes *idiopathic* or *spontaneous;* while the latter are termed *traumatic.*

In tabular form they may be classified as follows:—

**Pathological aneurysm.**—*Arterial.*—(*a*) Fusiform. (*b*) Sacculated. (*c*) Dissecting.

**Traumatic aneurysm.**—*Arterial.*—(*a*) Circumscribed. (*b*) Diffuse.

*Arterio-venous.* — (*a*) Aneurysmal varix. (*b*) Varicose aneurysm.

**Pathological aneurysm.**—*Causation.*—There are two factors in the production of an ordinary arterial aneurysm—weakness in the arterial wall and increase in arterial tension. The weakness of the vessel wall is generally associated with pathological changes which are the outcome of syphilis. Wassermann's reaction is positive in the majority of subjects afflicted with aneurysm. Sometimes an infective embolism has produced an arteritis, which in its turn has weakened an area of the vessel wall. The increase of arterial pressure is frequently the outcome of injudicious intermittent exercise, particularly in those who are no longer young. Chronic renal disease is also prone to raise arterial tension greatly, and to cause hypertrophy of the left ventricle and thus to bring about a vicious circle. Men suffer from aneurysm far more frequently than women. The age of onset is generally between thirty and fifty, the age at which the arteries are beginning to degenerate, whilst the activity of the man is little, if at all, lessened.

FIG. 96.—Senile gangrene. (A photograph kindly lent by Mr. G. P. Newbolt.)

Chronic arteritis, also known as arterio-sclerosis, is a type of degeneration which is seen with increasing age, and is in fact one of the signs of the wearing out of the vascular system. The expression that "a man is as old as his arteries" is literally true, for if this degeneration occurs in middle age the man rapidly becomes an "old man." The elastic and muscular elements of the arterial wall undergo great changes and are replaced by fibrous material, and the normal fibrous tissue found in the vessel wall is increased in amount.

Hence the artery becomes thicker, less elastic, and therefore less capable of expansion and contraction.

The causes of this degeneration are numerous, and a knowledge of them should help to prevent the onset of a condition which is the forerunner of many a fatality.

In one sense the lesion may be considered as a normal accompaniment of advancing age, but as the causes of the disease are more thoroughly investigated it is found that there is less and less ground for considering the degeneration other than pathological.

There are two chief reasons why this change in the arterial wall occurs—chronic intoxications and repeated increases of arterial tension. The chronic intoxications include those of syphilis, alcohol, lead, diabetes, rheumatism, and nephritis, though in the last instance the inflammation of the kidney itself may be the outcome of the same toxin rather than the actual cause of the sclerosis of the arteries

Increased arterial tension is caused by bouts of violent exercise, strain, possibly anxiety and sexual excess. The smaller arteries are frequently all involved in the disease, and fairly uniformly throughout their length. The larger vessels, on the other hand, may only show patches of the disease here and there. The big arteries at times also show definite yellow areas of fatty necrosis on their inner surfaces. These spots have been termed "atheromatous abscesses," and if the endothelium of the intima gives way the degenerated cells are cast into the blood-stream and are carried to distant parts, and may even cause embolism and thrombosis. At other times calcareous salts are deposited in the damaged wall of the artery and a plaque is formed, which is termed *secondary calcareous degeneration.*

There are two possible results of this degeneration of the arterial wall which may come under the view of the surgeon—gangrene and aneurysm.

The preventive treatment of arterial sclerosis is much more important than any attempt to treat the condition when once it is in evidence. Both the prophylactic, and the actual, treatment belong to the province of the physician.

**Varieties of pathological aneurysm.**—There are three forms of pathological arterial aneurysm usually described—the fusiform, the sacculated, and the dissecting.

**Fusiform aneurysm.**—A fusiform aneurysm is really a dilated and somewhat elongated artery, all three coats of the vessel entering into the formation of the aneurysm. Each of the coats, and more particularly the fibrous external coat, is thickened, so that the actual portion of a vessel constituting an aneurysm has a total thickness of the wall considerably greater than the normal vessel. The internal coat usually presents marked evidence of atheroma.

A fusiform aneurysm is hardly ever seen except in the aorta, and then it is more common in the thoracic portion than in the abdominal. In a large number of cases its development is slow, and there may be few, if any, signs and symptoms of its presence; in fact, in many instances it is not discovered except by *post-mortem* examination of a person who has died of some other disease. It is rare for clot to form in the sac, but if it does it may cause a spontaneous cure by obliteration of the lumen of the vessel. In some cases a fusiform aneurysm becomes converted into a sacculated one by a portion of the wall of the fusiform dilatation becoming weakened and allowing a local bulge to occur.

*Signs and symptoms.*—The signs and symptoms of a fusiform aneurysm which may be noticed are increased evidence of pulsation in the line of the

vessel, together with some tendency to pressure upon the surrounding structures, giving rise to pressure symptoms, such as pain, which may be either local or referred.

The *treatment* of a fusiform aneurysm is not by any means satisfactory, and as a rule must be entirely constitutional.

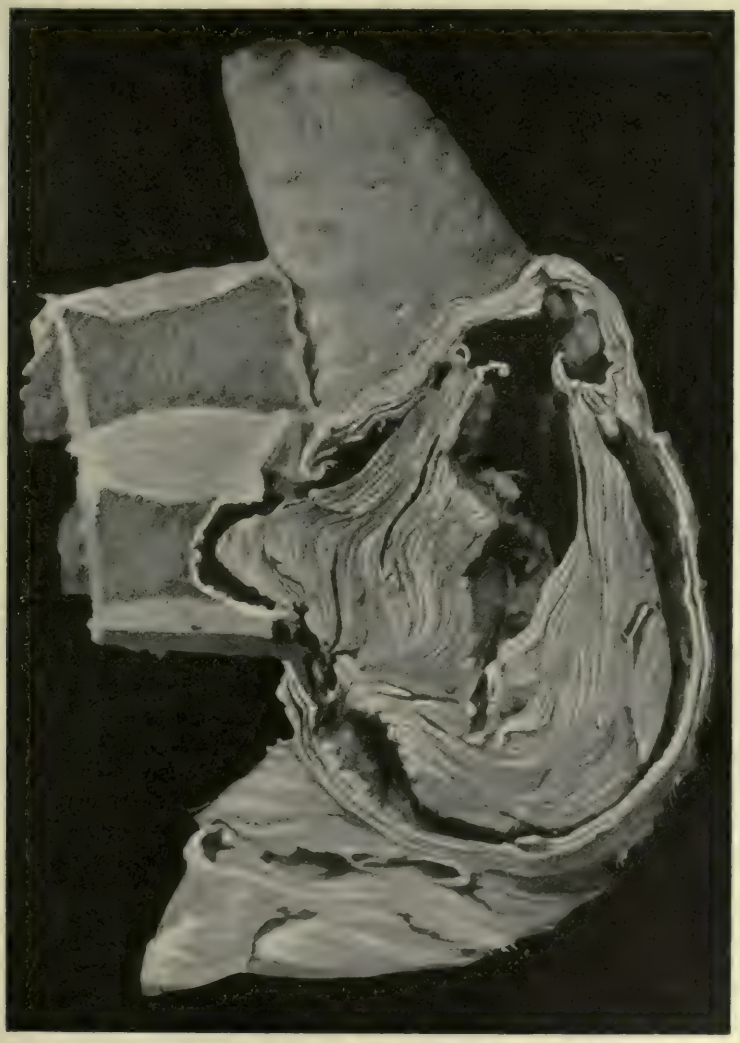


FIG. 97.—Erosion of the body of a vertebra by a sacculated aneurysm. (St. Bartholomew's Hospital Museum.)

**Sacculated aneurysm.**—A sacculated aneurysm is one in which the sac communicates with the artery through a comparatively small aperture, the sac wall consisting of the external coat alone, the internal and middle coats being absent. There is therefore some condensation and incorporation of some of the surrounding tissues, causing them to form part of the sac wall. In addition, clot may be deposited on the inner surface of the sac wall, thus increasing its thickness. If the sac of such an aneurysm be opened up it will

be found to contain a peripheral layer of fairly firm, laminated but partially-decolorised clot; within this, forming as it were the middle part of the contents of the sac, is often seen a mass of softish red clot; within this again, and close to the orifice of the sac, fluid blood, which in the living subject is passing from the artery into the sac and back again into the artery. It is this flow of blood into and out of the sac which in some cases leads to the detachment of clot, the formation of an embolism, and the blocking of a distal artery. A sacculated aneurysm may occur in almost any artery on the body, and it may vary from the size of a small pea up to that of a cricket-ball.

When a sacculated aneurysm occurs upon one of the large arterial trunks contained within the thorax or abdomen it is called an internal aneurysm, but when it occurs upon one of the vessels of the limbs it is termed an external aneurysm.

The presence of a sacculated aneurysm as a rule has marked effects which produce definite signs and symptoms.

*Effects of a sacculated aneurysm.*—These are almost wholly due to pressure upon the surrounding structures, or upon distal vessels in which the circulation will be affected. Pressure upon the surrounding structures shows itself chiefly in two ways—by pain, which may be local at the site where the aneurysm is being formed, or referred owing to the pressure of the sac upon the main nerve trunk (as a rule the sensory parts of a mixed nerve are much more definitely interfered with than the motor fibres), or by œdema of the distal portion of the limb owing to obstruction by the aneurysmal sac of the return flow of blood through the adjacent veins.

When the aneurysm comes into contact with resistant tissues, such as bone or cartilage, these undergo absorption, and the more resistant the structure the greater the amount of the absorption. Thus, if an aneurysmal sac is pressing against the spine the bone forming the bodies of the vertebræ becomes greatly absorbed, while the intervening intervertebral discs are but little affected. This is partly owing to their greater elasticity and therefore greater power of resisting the intermittent pressure of the pulsating sac, and partly to the absence, in cartilage, of the blood-vessels necessary for the production of a rarefying inflammation.

The pressure of an aneurysm generally causes a considerable amount of chronic inflammation of a plastic character in the tissues immediately in its vicinity; hence the parts become matted together, which matting, together with their displacement owing to the pushing force of the aneurysm, very greatly alters their anatomical relations.

The effect of an aneurysm upon the circulation is two-fold. The artery distal to the sac does not receive its normal supply of blood, so that the distal pulse is smaller than on the sound side, and the dicrotic wave may be absent from its beat. Further, there is, as a rule, a delay in the time of the beat in the distal vessel, so that when compared with the other side the difference may be very marked. The smallness of the distal pulse and its delay are probably due in part to the pressure of the aneurysmal sac upon the artery on the proximal side of the lesion. Sometimes the artery from which the aneurysm arises may become blocked with clot, and this again causes serious interference with the arterial supply of the distal part of the limb.

*Signs of a sacculated aneurysm.*—A sacculated aneurysm always forms a tumour, but this tumour may be so small as to pass without recognition; on the other hand, it may be so prominent as to be quite self-evident. The swelling is always found in close apposition to an artery, and in most cases actually in the line of the vessel. As a rule the swelling can be moved laterally,

but not in the axis of the artery, and therefore it cannot be lifted away from the vessel to which it is attached.

A sacculated aneurysm pulsates, and the pulsation is synchronous with the heart's beat. The tumour expands each time the systole of the heart drives blood into its cavity. This expansile pulsation is a most characteristic feature of a sacculated aneurysm. The pulsation ceases when the main artery feeding the sac is compressed on the proximal side of the aneurysm. At the same time the size of the sac diminishes and the tension within it becomes less. If the pressure is removed, the aneurysm refills with one or two beats of the heart, and the pulsation resumes its expansile character. A bruit is heard over the swelling, which is systolic in time and usually loud and harsh, sometimes blowing in character, and it may be increased in force by pressure from the stethoscope. Sometimes a very distinct thrill is felt by the fingers placed on the skin over the swelling. An examination by X-rays generally indicates the presence and extent of the aneurysmal swelling.

*Symptoms of a sacculated aneurysm.*—The chief symptom of an aneurysm is pain. As a rule the pain is due to pressure upon the surrounding structures, particularly when nerves are adjacent. The pain is usually constant and is sometimes mistaken for the pain produced by rheumatism, and this is particularly apt to be the case when the aneurysm occurs in one of the extremities. Occasionally, sharp cutting pains may be felt, not at the site of the aneurysm itself, but in the areas of distribution of the cutaneous nerves distal to the sac.

*Diagnosis of a sacculated aneurysm.*—There are four conditions which have to be diagnosed from an aneurysm.

1. Abnormal pulsation in arteries.
2. A tumour overlying an artery.
3. A tumour underlying an artery, and raising the vessel on its surface.
4. Pulsating vascular tumours.

*Abnormal pulsation in arteries.*—Where an artery has become somewhat dilated, and particularly where at the same time it has become tortuous, abnormal pulsation may occur and may be mistaken for a true aneurysm. There is, however, no definite localised swelling, and the pulsation is evidently that of the vessel itself. Moreover, if the condition occurs in an extremity, the opposite limb will often show a similar if not identical condition.

*A tumour overlying an artery.*—This is by no means an uncommon condition, and when the swelling is present over a superficial vessel pulsation of the artery may be transmitted to it. The pulsation, however, is not expansile, and when the tumour is lifted off the artery the pulsation will cease. If the main vessel on the proximal side is compressed pulsation will be no longer present, but the tumour will not diminish in size. There is seldom, moreover, a bruit to be heard, and, if one should be present, it is quite different from that which is obtained on listening over an aneurysm. It is very rare to get any alteration in the pulse distal to the swelling. Sometimes a tumour associated thus with an artery is cystic in character, and occasionally such a cyst, as for instance in the popliteal space, may communicate with the knee-joint, and so pressure upon it may cause diminution in its size by its fluid contents being emptied into the joint. When such pressure is removed the swelling fills gradually, and not by jerks, as in the case of an aneurysm.

*A tumour underlying an artery and raising the vessel on its surface.*—When this occurs the artery will be raised and a line of pulsation will be detected over the swelling. If, however, two fingers be placed on either side of the swelling itself no expansile pulsation will be found, nor does the tumour

become less when the main artery on its proximal side is compressed, although the pulsation will cease.

*Pulsating vascular tumours.*—An endosteal sarcoma, if allowed to progress, not infrequently exhibits marked pulsation. This is particularly the case in the head of the tibia, but, although the pulsation will cease when the main artery on the proximal side is compressed, there will be no diminution in the size of the swelling. So-called egg-shell crackling may be felt over the tumour and an X-ray photograph will show the expansion of the bone and complete the differential diagnosis.

A pulsating goître in the neck may present considerable difficulties in its diagnosis from an aneurysm. If, however, the common carotid a tery is compressed on the proximal side, very little, if any, diminution in the swelling will occur, so that the tumour will be readily recognised as belonging to the thyroid body.

*Terminations of a sacculated aneurysm.*—Most commonly a sacculated aneurysm steadily increases in size and eventually ruptures, but in a certain number of cases a spontaneous cure results, and in a few suppuration occurs. As the aneurysmal sac increases in size its walls necessarily become thinned, with the result that the weakest portion of the wall of the sac gives way and a rupture of the aneurysm occurs. Such a *rupture* may take place through skin or mucous membrane, through a serous or a synovial membrane, or into the tissues surrounding the sac. When the rupture takes place through skin or mucous membrane there is usually a break in the overlying tissue, producing a small ulcer; through this a small quantity of blood is lost, and then as the ulcer increases in size a greater quantity of blood pours forth, until at last a fatal gush occurs. When the aneurysm ruptures into one of the hollow viscera, such as the stomach or intestine, signs of internal hæmorrhage will occur, no blood being lost externally. Rupture into the trachea or a bronchus may lead to the patient being suffocated by his own blood. Rupture into a serous or synovial cavity is frequently by a large slit-like aperture producing very rapid and severe internal hæmorrhage.

*Subcutaneous rupture*, as a rule, is in the form of a small leak to start with, blood being extravasated into the tissues and progressing along the line of least resistance. Much pressure is thus brought about, with the result that the veins are obstructed and gangrene occurs in the distal portion of the limb.

*Spontaneous cure of a sacculated aneurysm* may come about by extension of clot from the interior of the sac into the lumen of the artery, thus blocking the entrance into the sac and preventing further blood from gaining admission; or the pressure of the sac upon the main artery upon the proximal side may so diminish the amount of blood entering the sac that laminated clot is deposited until it fills the whole of the interior of the sac. Another way in which spontaneous cure may occur is by the displacement of clot from the interior of the sac into the main vessel on the distal side, thereby causing a cessation of the blood-stream in the sac and the deposition of clot so as to obliterate its cavity.

*Suppuration of an aneurysm* is brought about by the infection of the tissues round the sac. There is some redness and œdema of the superficial parts, much pain and tenderness, and an increase in size of the tumour, which usually ceases to pulsate. These signs may be accompanied by fever and other general symptoms of suppuration. Before long the sac wall ulcerates through, and severe hæmorrhage occurs either into the surrounding tissues or externally through the skin, and death rapidly follows. In a few instances,

however, suppuration may lead to an inflammation of the artery on the proximal and distal side of the sac, whereby obliteration of its lumen occurs and a cure of the aneurysm results.

**Treatment of a sacculated aneurysm.**—The treatment of a sacculated aneurysm is both general and local. *General treatment* resolves itself into rest, partial starvation and drugs. Rest is attained by keeping the patient in bed, and as far as possible in the dorsal position, and avoiding all sources of mental worry. Partial starvation is brought about by gradually limiting the daily food to about 6 oz. of bread with 1 oz. of butter, 2 oz. of meat and 6 oz. of milk, or 3 oz. of milk and 3 oz. of water.

Medicinally, large doses of iodide of potassium, such as 15 to 20 grains, should be given three times a day, and a dose of some preparation of opium nightly to induce sleep and mitigate the desire for a larger quantity of food.

**Local treatment of a sacculated aneurysm.**—The local treatment of a sacculated aneurysm may be carried out in a number of different ways, of which the following may be given as the chief :—

1. Incision and obliteration of the aneurysmal sac.
2. Excision of the sac.
3. Ligature of vessels.
4. Pressure, either upon the sac or vessels.
5. The introduction of foreign substances into the sac.
6. Amputation of affected limb.

1. *Incision and obliteration of the aneurysmal sac.*—This method is frequently called after the name of its originator, Matas, and may be termed endo-aneurysmorrhaphy. It can be carried out only in those cases in which the circulation through the aneurysmal sac can be temporarily controlled. A tourniquet is first of all applied to the limb on the proximal side of the sac, or if such a proceeding is impossible the main artery is exposed and for the time being occluded by a temporary ligature. When it is ascertained that the flow of blood into the aneurysmal sac has been completely controlled, the sac itself is freely opened and emptied of any blood and blood-clot which it may contain.

The ideal method is to close the mouth by which the sac communicates with the main vessel in such a way as not to obliterate the lumen of the vessel itself. Sutures of fine silk are inserted across the mouth of the sac and tied within its cavity. The pressure, or the temporary ligature,

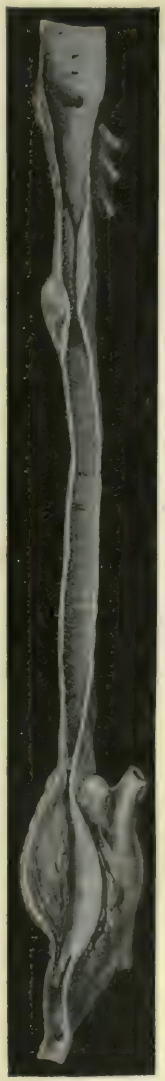


FIG. 98.—View of the femoral and popliteal arteries, five years after ligature of the superficial femoral for the cure of a popliteal aneurysm. At the upper part of the specimen the vessel has been occluded by the ligature. The aneurysm is completely consolidated, and the artery here also is no longer patent. Between the seat of ligature and the aneurysm the lumen of the vessel is open.

upon the proximal vessel is then removed, and, provided no blood escapes, the sac wall itself is doubled in and its surfaces held together by a stitch or two passed through the skin and the sac wall and tied over small rolls of gauze. The advantages of this method are two-fold—namely, that the main arterial supply of the limb is not interfered with and there is little or no risk of injury to structures outside the sac, such as the adjacent veins or nerves.

2. *Excision of the sac.*—After endo-aneurysmorrhaphy, ligature of the main vessel on the proximal and distal side and excision of the sac is the best method. And, moreover, because excision can be carried out sometimes where the former method is impossible, this second method is considered by some to be the best of all. A good example in which ligature and excision is desirable is that of a sacculated aneurysm connected with the popliteal artery. Here, after a tourniquet has been applied to the thigh—that is, on the proximal side of the sac—a free incision is made down to the posterior aspect of the tumour, and with care, particularly in reference to the vein, the feeding artery is exposed on the proximal side of the sac, ligatured in two places near one another, and divided between the ligatures. Similarly the artery is exposed on the distal side of the sac and again doubly ligatured and divided. Next the sac itself is carefully disconnected from the surrounding tissues, and, any branches coming off from the artery between the two places being secured, the sac and the portion of the vessel opposite it are removed from the wound. Subsequently the distal portion of the limb must be well protected from cold and somewhat elevated as well as being kept at rest.

Sometimes gangrene follows this proceeding, and it is due either to deprivation of the distal parts of their arterial blood supply or to the want of proper return of blood from the periphery owing to damage to and thrombosis within the main vein.

3. *Ligature of vessels.*—Ligature in the treatment of an aneurysm may be either proximal or distal to the sac. When *proximal*, the ligature is applied to the main artery, and it may be placed upon the vessel at some distance from the sac or close to it. Probably the better method is the former, and for the following reasons. The artery in this position lies in its normal anatomical relations, is less likely to be markedly diseased, and there is room between the site of the ligature and the aneurysmal sac for some collateral circulation to be formed whereby a slow and small stream of blood may enter the aneurysmal sac and deposit laminated clot. On the other hand, an attempt to place a ligature upon the artery close to the sac may be very difficult on account of the altered anatomical relations, and damage may be done either to the corresponding vein, which may lead to gangrene, or to the sac itself, which may lead to hæmorrhage.

*Distal* ligature may be either upon the main artery or upon one or other of the branches into which the main vessel divides. Distal ligature is used only where the artery on the proximal side cannot easily be reached. In order that a distal ligature may be effective no lateral branches should leave the artery between the position of the sac and the site of the ligature. Such an anatomical condition is perhaps best seen in the case of a distal ligature placed upon the common carotid just before its bifurcation for the cure of a sacculated aneurysm on the vessel at the root of the neck.

4. *Pressure, either upon the sac or vessels.*—Pressure may be applied upon the main artery on the proximal side of the sac, or upon the sac itself by means of flexion at the elbow or the knee, or upon the artery on the distal as well as upon the proximal side of the sac. *Proximal* pressure is generally

secured by the application of the fingers of relays of assistants, helped by a weight so slung as to touch the compressing digits. Pressure upon the vessel may also be applied by a tourniquet. Such a method of treatment for an aneurysm is seldom employed at the present day because it is uncertain, painful, and tedious.

Flexion of the elbow or knee is only suitable for small aneurysms in the bend of the elbow or in the popliteal space ; in either case compression occurs upon the sac itself, and possibly in some instances also upon the artery on the proximal side. It is, again, an uncertain and painful method and very seldom employed.

Pressure upon the artery distal and proximal to the sac is carried out by the application of a rubber bandage to the distal portion of the limb up to the sac, but not over it, and then on the proximal side of the sac almost up to the trunk. This pressure causes pain and has to be maintained for about one hour and a half, and consequently an anæsthetic is necessary.

5. *The introduction of foreign substances into the sac.*—Such a method has for its object the induction of clotting within the sac, and is only used where other methods cannot be undertaken. There are several different ways in which this line of treatment may be carried out. For instance, a very fine, smooth steel needle may be introduced obliquely through the wall of the exposed sac and allowed by the movement transmitted by the pulsation to scratch the opposite wall of the sac, and in this way roughness and clotting are produced.

Another method is to pass in a needle and to connect it with the positive pole of a battery, the other pole being attached to a flat electrode placed at a distance on the patient's skin. In this way electrolysis will occur and clotting ensue.

In yet other cases, and in some of the aneurysms of the abdominal aorta with success, many feet of fine steel wire, such as piano wire, are introduced and allowed to remain within the sac. A wire expanding cage may also be introduced through a canula.

6. *Amputation of affected limb.*—Lastly, when the aneurysm is in a limb, particularly if it has begun to leak or gangrene is threatened or present, amputation on the proximal side of the sac is strongly indicated.

**Dissecting aneurysm.**—A dissecting aneurysm is practically never seen except in the aorta and its large branches. It is a rare disease, and it is said to be more common in women than in men. As a rule it begins in some part of the thoracic or abdominal aorta at a point where there is a so-called atheromatous ulcer. The blood is forced through the base of the ulcer into the space between the outer and middle coats of the artery, dissecting the one from the other ; it sometimes finds its way back again into the lumen of the vessel through the inner and middle coats at a point some distance away from its origin.

*Symptoms.*—A patient who is suffering from atheromatous disease of the large arteries may be seized suddenly with severe pain in the back and trunk, closely followed by coldness, pain and numbness of the lower limbs, due to the fact that they are not receiving the proper amount of blood owing to the lumen of the aorta being partially blocked by the pressed-in and possibly folded-back inner and middle coats. The condition is a very serious one, often leading rapidly to death, and no *treatment* appears to be of any avail.

**Traumatic aneurysm.**—Traumatic aneurysms are either purely arterial or partly arterial and partly venous.

**A traumatic arterial aneurysm** is usually described as being of two varieties

—circumscribed or diffuse. The former is a true aneurysm; because it has a distinct sac wall. The latter should not strictly be called an aneurysm, because it does not possess a true sac wall. When an artery is wounded subcutaneously, and provided the wound is not a severe one, some hæmorrhage occurs into the tissues, but the bleeding then stops and the wound of the vessel soon heals. In some cases, however, pressure of the blood within the vessel causes the weak area, where the scar is, to bulge, and gradually a definite sac is produced, partly by the dilatation of the vessel wall and partly by the condensation of the tissues around; this is a circumscribed traumatic aneurysm. Such aneurysms are most commonly observed in the hand, foot, or scalp. They present all the characteristics of an ordinary pathological sacculated aneurysm, and their course and terminations are the same.

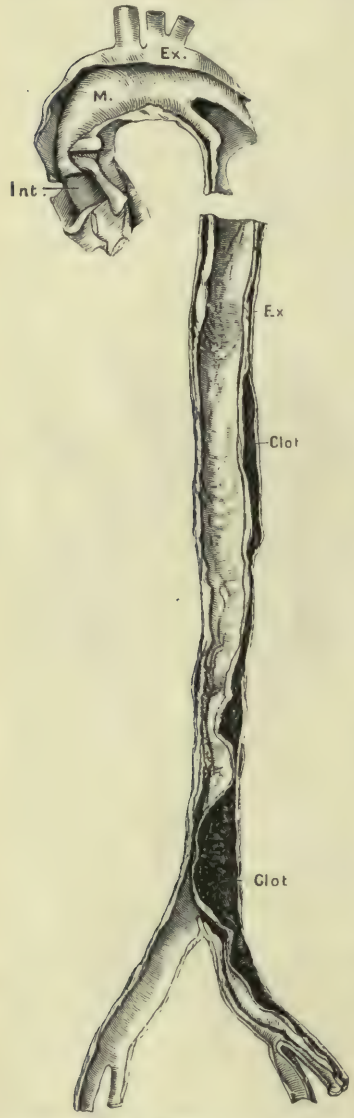



FIG. 99.—A dissecting aneurysm of the aorta. The internal and middle coats have given way one inch above the valves, and the blood has separated the outer coat from the middle the whole length of the aorta and has extended between the coats of the left common and external iliac. EX. External coat; M. Middle coat; INT. Internal coat. (St. Bartholomew's Hospital Museum.)

*Treatment* is best carried out by ligature and excision in the manner described in connexion with the sacculated aneurysm.

When an artery is so severely wounded subcutaneously that blood is poured out rather rapidly into the tissues, a diffuse traumatic aneurysm results. Such an extravasation of blood leads to pressure upon the corresponding veins, and frequently causes gangrene. If seen sufficiently early the clot should be turned out through a large incision, and the vessel ligatured on either side of the leak. Failing this, amputation of the limb will be necessary.

**Arterio-venous aneurysm.**—There are two forms of traumatic aneurysm, involving both an artery and a vein. The one is that known as an *aneurysmal varix*, and the other as a *varicose aneurysm*.

An *aneurysmal varix* has no true sac between the artery and the vein, the connexion between the two vessels being direct. Such a condition is usually the outcome of stabs or gunshot wounds, the artery and vein which lie close to one another being both of them injured together. The condition is usually readily recognised by the history of an injury and by thepresence of a pulsating tumour at the site of the communication, together with marked varicosity of the veins distal to it. If a stethoscope be placed

over the swelling a very loud bruit will be heard which is not unlike the buzzing of a bee in a box. Pain may be very severe, both at the site of the swelling and in the distal parts of the limb.

A good deal of congestion and some œdema of the parts distal to the aneurysmal sac will be seen.

The *treatment* of the condition is either expectant or else to expose the lesion and to ligature both artery and vein on both the proximal and distal sides of the communication.

A *varicose aneurysm* is a communication between an artery and a vein, but through a definite intervening aneurysmal sac. The signs and symptoms are very similar to those of an aneurysmal varix, except that dilatation of the distal vein is not usually present.

*Treatment* consists of ligature of both the artery and the vein on the proximal as well as the distal side, together with the excision of the intervening sac. In very rare instances, however, it may be possible, and therefore desirable, to separate the sac both from the artery and the vein, and to suture the opening in each vessel without obstructing the lumen of either and thus to maintain the circulation of the limb.

## Collateral Circulation.

In every case in which the flow of blood in a main regional artery is blocked, either by nature or ligature, the vitality of the distal parts depends upon the establishment of an efficient collateral circulation. By this is meant the opening up and enlargement of the anastomoses between branches of the main vessel given off above the block with those below it. At the same time the direction of the flow of blood in the latter is reversed, so that the blood flows through them into the main vessel below the block, and is thence carried to the distal parts. The factors concerned in this process are probably as follows :—

1. A reactionary afflux of blood in the branches immediately above the block, elicited as a result of a stiumulus from the distal bloodless tissues.
2. Active vaso-dilatation of the small vessels concerned.
3. An increase in the general arterial pressure, resulting from the cutting off of a portion of the arterial system by the block in the main vessel.

The establishment of the collateral circulation usually takes place within a few days of the occlusion of the vessel, and should be encouraged by keeping the part elevated and warm. The process may be delayed or altogether prevented by :—

1. Disease of the arteries, such as arterio-sclerosis.
2. A severe crushing injury to the tissues.
3. Pressure upon the small vessels, as by a large aneurysm or an extensive hæmatoma.
4. Venous stasis in the distal parts owing to the simultaneous occlusion of the main vein.
5. Anatomical reasons. In certain regions the anastomoses are much more free and numerous than in others.

If the collateral circulation fails to be established, gangrene sets in.

## Aneurysms of Special Arteries.

Although aneurysms are much less common apparently at the present day than they used to be, it may be well to give a brief indication of some of the more important signs and symptoms of those aneurysms which are amenable to surgical treatment.

**Thoracic aorta.**—It is only when the arch of the aorta is the site of a sacculated aneurysm that any hope can be held out of benefit from surgical treatment, and even then the prospect of cure is very remote. Such a sacculated aneurysm can be most easily diagnosed by its pressure effects and by the shadow seen in a skiagram. The pressure effects are those of pain, congestion owing to interference with the return of blood through the super or cava, and paralysis of the muscles of the larynx owing to interference with the function of the left recurrent laryngeal nerve. In some cases a very characteristic tracheal tug is present.

*Treatment.*—The only surgical treatment that can be of any service is to try and bring about obliteration of the sac by the introduction of foreign bodies, or by the process of needling already described.

**Innominate artery.**—An aneurysm of this artery usually makes itself known by the appearance of a pulsating tumour behind the lower end of the right sterno-mastoid muscle. There is pressure on the brachial plexus, in many cases causing severe pain, and sometimes actual paralysis of the right upper extremity. The pulse in the radial artery on the right side is very frequently considerably delayed, and the same phenomenon may be observed in the right common carotid artery.

*Treatment.*—Since there is no room for the application of a proximal ligature, which in itself would be a difficult and hazardous proceeding, the surgeon can only have recourse to distal ligature of the right common carotid artery and the third part of the right subclavian artery, or the less satisfactory method—the introduction of foreign bodies into the sac.

**Common carotid artery.**—An aneurysm of this artery is one which is not infrequently seen in women, being the most common external aneurysm met with in the female sex. It develops either just before the bifurcation of the vessel or quite low down at the root of the neck. It presents the general signs and symptoms of an aneurysm. Dyspnœa, accompanied frequently by cough, is one of the most urgent of the pressure symptoms. An aneurysm of the left common carotid artery presses upon the left side of the œsophagus and causes some dysphagia. Such an aneurysm sometimes gives rise to difficulty in diagnosis, since quite a number of swellings rising in the neck have a close relationship with the vessel, while in other cases tumours connected with the thyroid body may pulsate and so simulate an aneurysm.

*Treatment.*—When the distal portion of the artery is the site of the aneurysm a proximal ligature on the common carotid is the best treatment, but if the tumour is at the root of the neck, a distal ligature may be highly satisfactory, because there are no branches leaving the vessel between the aneurysm and the site of ligature.

Occlusion of the common carotid artery may lead to dangerous anæmia of the corresponding side of the brain. In fact, so great may be the deprivation of blood that progressive cerebral softening may ensue.

**Subclavian artery.**—An aneurysm upon this vessel is seen more frequently on the right than on the left side, and in men whose work leads to considerable strain upon the structures in the axilla. The third part of the artery is the common site for the aneurysma' sac.

Pressure upon veins early causes congestion and œdema of the hand and forearm. Pressure upon the brachial plexus soon produces pain and sometimes paralysis. When the aneurysm affects the first or second portions of the artery the phrenic nerve hardly ever escapes pressure, and this compression may produce serious interference with the proper action of the diaphragm. The radial pulse on the same side is small and delayed. Some-

times the normal subclavian artery is raised by the presence of a cervical rib, causing the pulsation of the vessel to become much more marked, and to simulate that of an aneurysm.

*Treatment.*—The surgical treatment of a subclavian aneurysm depends a good deal upon the position of the sac. If this is in the third part, it may be possible, but difficult, to apply a proximal ligature, but, in the majority of cases, distal ligature with amputation of the upper extremity at the shoulder-joint holds out the greatest chance of success.

**Abdominal aorta.**—Any part of this large arterial trunk may be the site of an aneurysmal dilatation, or of a true sacculated aneurysm. As a rule a markedly pulsating tumour is present, the pulsation of which is definitely expansile. It is in this region, perhaps of all others, that a tumour overlying the vessel may most closely simulate an aneurysm. A skiagram may indicate the presence of an aneurysmal sac when all other methods of diagnosis have failed.

*Treatment.*—The only method of treatment open to the surgeon in the majority of cases is the introduction of foreign bodies after an abdominal section.

**Gluteal artery.**—When an aneurysm forms upon this vessel, or the sciatic, it gives rise to a deep-seated swelling in the buttock.

It is important to remember that because of the pain, and possibly also some superficial œdema, and particularly when leakage occurs, the condition may very closely simulate a deep-seated abscess. Such a mistake may prove disastrous if it leads the surgeon to make an incision without realising the nature of the case.

*Treatment.*—The internal iliac artery should be exposed by the transperitoneal route and ligatured.

**Popliteal artery.**—This vessel is one of the most common sites for an aneurysm, probably owing to the fact that the artery is so frequently kinked during flexion and is so little supported in the popliteal space. Pain is very constant, and in the earlier stages, when the tumour formed by the aneurysm has been overlooked, rheumatism has been diagnosed and an improper treatment thereby carried out. Pressure upon the popliteal vein soon causes congestion and œdema of the foot and leg, while compression of the nerves in the popliteal space leads to pain and even paralysis.

*Treatment.*—When small, excision is probably the safest method of dealing with the condition. When further advanced, reconstructive endo-aneurysmorrhaphy may be attempted, and if this is impossible ligature of the superficial femoral artery at the apex of Scarpa's triangle should be carried out.

**Pulsating exophthalmos.**—When a patient exhibits proptosis, with puffiness of the eyelids and congestion and œdema of the conjunctiva, pulsation of an expansile character and a thrill can generally be felt in the orbit. Later the muscles of the eyeball become paralysed, and blindness may follow owing to optic atrophy. Such a condition may be produced by a number of different lesions, such as an aneurysm of the ophthalmic artery, an aneurysmal varix between the carotid artery and the cavernous sinus, thrombosis of the cavernous sinus, traumatic aneurysm of the internal carotid artery in the cavernous sinus, a plexiform angioma within the orbit, and a pulsating sarcoma growing from the walls of or invading this cavity.

The *diagnosis* as to the precise lesion present is exceedingly difficult. The *treatment* is by no means satisfactory, except where pressure upon the common carotid artery diminishes all the signs, particularly that of pulsation, in which case ligature of the internal carotid may bring about a cure.

## Wounds of Veins.

The veins of the body are superficial and deep. While the deep veins may be injured by penetrating wounds, damage to them is not very frequent. The superficial ones, on the other hand, are much exposed to injury.

The *immediate result* of a wound of a vein is loss of blood, and in certain positions the entrance of air into the vein.

**Hæmorrhage from the wound of a vein.**—It is uncommon for a division of a vein, even a large one, during an operation, to be accompanied by much loss of blood. A normal vein has a thin wall, which easily collapses when it is severed and bleeding is thereby arrested. Further, the divided vessel is usually promptly occluded by the application of pressure forceps. The accidental severing of a vein, and particularly a wound of a dilated vein, may be followed by a considerable loss of blood, generally from want of appropriate treatment.

The *treatment* of hæmorrhage from a vein is either pressure or ligature. Pressure very readily occludes a wound in small and medium-sized vessels. It may be applied to small veins by means of an aseptic swab, or by gauze plugging. The large veins, on the other hand, should always be ligatured, and by a double ligature, a distal and a proximal.

In some cases venous hæmorrhage may be from a vessel placed very deeply, and exceptionally it may be desirable to leave a pair of pressure forceps *in situ* for forty-eight hours rather than to run the risk of further injury to the vein by a futile attempt to secure it by ligatures. In aseptic wounds a superficial suture should be inserted, but left untied until after the forceps have been very carefully taken off.

In some cases a tributary to a large vein has to be severed close to the main trunk. It may then be possible to pick up the hole in the wall of the vessel and secure it by a carefully-applied lateral ligature. The same can be carried out when a punctured wound causes bleeding from a small aperture in the vessel wall. A longitudinal slit in the wall of a large vein may be sutured with fine silk, gentle pressure being made on the proximal and distal side of the rent to arrest the bleeding during the stitching. Both by lateral ligature and suturing it is possible to stop hæmorrhage without arresting the blood-stream through the vein.

A vein is at times severed, generally in operation wounds, where the vessel is lying in bony tissue or unyielding fibrous tissue. For this reason the walls of the vein cannot adequately collapse, and bleeding continues. There are two methods of stopping such loss of blood when there is osseous substance around the vein—the first is to crush the bone in the immediate vicinity; the second is to press in some aseptic wax, so as to occlude the open mouth of the vessel. When there is dense fibrous tissue around the bleeding vessel a fully-curved needle carrying a silk suture should be passed deep to the vein and the silk thus carried around it and then tied.

**Entrance of air into a vein.**—The entrance of air into a vein is due to the negative pressure in the thorax, particularly during inspiration. The effect of this pressure diminishes the further the vein is away from the chest. Hence it is only after wounds of veins at the root of the neck that any real danger of air entry exists. Here another factor is also at work. The passage of a superficial vein through, and the attachment of the walls of the vein to, the deep cervical fascia prevent the collapse of the vein, its walls being, as it were, held open. Such an accident is very rare at the present

day, because all surgeons when operating on the lower part of the neck are on their guard against it.

There are four points to be remembered in the prophylaxis of entry of air into cervical veins during operations: never to divide a vein without first securing it by forceps or ligature, never to pull on a tumour so forcibly as to tear through small tributaries near their entrance into the main vein, always to make an incision sufficiently large to allow of easy dissection, and always to have a good light thrown right into the depths of the wound.

Air entry is recognised by a hissing sound, and, if much is allowed to pass in, by the rapid cyanosis and inevitable collapse of the patient. Immediate pressure should be applied by the surgeon's finger on the proximal end of the vein, the distal portion being allowed to bleed so as to fill the wound with liquid blood. If not enough blood escapes promptly for this purpose, the wound should be flooded immediately with aseptic saline. The finger may then be removed cautiously and an attempt made to seize the proximal end of the vein in a pair of forceps. No attempt should be made to ligature the vessel at once, provided the forceps are properly occluding the vein and the wound is kept flooded with fluid; but attention should be turned to helping the patient during the period of embarrassment.

The remote results of wounds of veins are phlebitis, thrombosis, œdema of the distal parts, pyæmia, and secondary venous hæmorrhage.

## Phlebitis.

Phlebitis is inflammation of the walls of a vein.

**Varieties of phlebitis.**—It may be simple, that is, non-infective, and is then due to injury, such as that which is seen in a bruise, or to pressure, such as that produced by a garter. Veins when in a state of varicosity are particularly liable to this form of phlebitis.

The other variety of phlebitis is the infective, and is usually seen when the walls of the vein are invaded by organisms present in the tissues outside the vein, or by bacteria lodged in a thrombus which has formed within the vein. In both cases inflammation of the tissues surrounding the vein (peri-phlebitis) may occur, and in the latter suppuration not infrequently follows.

*Signs and symptoms.*—Phlebitis of a superficial vein is characterised by a hard painful swelling in the line of a vein, the skin over it becoming congested and œdematous. When a main deep vessel is involved much engorgement of the distal portion of the limb occurs, leading in some cases to what is called solid œdema (" white-leg ").

Thrombosis occurs as a result of simple phlebitis, and portions of the clot may be carried away as emboli, and it is embolism which constitutes so great a danger in these cases.

Infective phlebitis is a very serious condition owing to the liability to general infection, resulting in pyæmia and not infrequently death. There is almost always marked fever, and not uncommonly a succession of rigors.

*Treatment.*—Rest is essential, and, if the inflammation is that of veins of the lower extremities, rest in bed should be ordered. The limb should be elevated in order to help the return of blood from the distal parts, and in many cases slinging the limb is helpful. The area of the inflamed veins should be covered with glycerine and belladonna applied rather thickly, and wrapped in cotton-wool or gamgee tissue and disturbed as little as possible. If, after acute inflammation has passed off, the thrombosed area remains tender and painful, it may be excised with great benefit. If suppuration occurs in

connexion with one of the superficial veins, a proximal part of the vein should be exposed and ligatured and then the suppurating area excised.

## Thrombosis.

Thrombosis is the clotting of blood within the living blood-vessel. The clot which is formed is called a thrombus. When the clot is formed within an artery it is called an arterial thrombus, and when within a vein a venous thrombus. Thrombosis is more common in veins than it is in arteries.

Fig. 100.—A large artery blocked by an embolus. (St. Bartholomew's Hospital Museum.)

The causes of thrombosis are various, but an injury to the vessel wall or inflammation of its coats, particularly those of a vein, or degeneration of vessel walls, are all common factors in the production of clotting, but in addition it must always be remembered that changes in the constitution or rate of flow of the blood in the vessel have a distinct bearing upon the formation of the thrombus.

When a thrombus forms in an artery it may so block the vessel as to cut off the blood supply to the peripheral parts, and gangrene, usually of a dry character, may ensue; on the other hand, when a thrombus occludes a large vein in the limb, it will prevent the proper return of blood and the distal parts will become greatly engorged. This also may lead to gangrene, but of the moist variety.

A thrombus in a vein may become converted into connective tissue, and the venous channel will thus be permanently blocked.

Sometimes calcification occurs in this old thrombus, and a phlebolith results which may be seen in a skiagram. If a thrombus is infected by

pyogenic organisms suppuration will almost certainly occur, and general infection may take place through the blood-stream.

## Embolism.

A separated thrombus is an embolus. When it is carried in the blood-stream to a distant vessel and blocks the lumen of that vessel, embolism occurs.

Other substances besides a blood-clot may produce embolism. Fat, usually obtained from the medullary cavity of fractured bone, or friable malignant tissue, such as sarcoma, may invade the lumen of the veins, and portions of the growth may be carried away in the blood-stream and produce embolism. Parasites, such as filaria, or the ova and scolices of the tapeworm may find their way into the blood-vessels, blocking them at a distance, and, lastly, air itself, being drawn into veins, may pass to the pulmonary vessels and may cause air embolism.

The following are the chief results of embolism of arteries:—Anæmia occurs in the part previously supplied by the artery which is now blocked, and, if that vessel happens to be a terminal one, necrosis of the affected areas occurs. This will be seen in the so-called white softening of the cerebral tissue as a result of the blockage of the small cerebral vessels. An infarction is a similar condition occurring in such an organ as the kidney or spleen.

If the embolus contains pyogenic bacteria, pyæmic abscesses are almost certain to occur at every spot to which they are carried. If such an embolism is arrested in an artery, the artery wall is softened by the subsequent inflammation and an aneurysm may form. If embolism occurs in the main artery of a limb, particularly the lower extremities, gangrene may follow. Such a sudden plugging, say of the popliteal artery, is due to the fact that the embolism is arrested owing to the bifurcation of the vessel in the lower part of the space and to the artery being bent when the knee is flexed. The arrest of the clot is accompanied by a sudden sharp pain at the point of arrest, a sensation of numbness and coldness in the parts beyond, and absence of the pulse in the distal portion of the vessel.

## Varicose Veins.

A varicose vein in the lower extremity is a very common lesion. Anything from a mere dilatation of a vein up to an enormous varix is classified under the heading of "varicosity."

There are three chief forms of varicose veins:—

1. Simple dilatation of a large superficial vein. This is frequently seen in the internal saphenous vein, and is often hereditary.

2. Dilatation, with lengthening and tortuosity, and distinct varices of several superficial veins, not only a main vessel.

3. Dilatation of superficial venules, resulting in discoloured patches in the subcutaneous tissues.

Varicose veins may also be classified as—(*a*) simple, (*b*) tortuous, and (*c*) congestive.

*Etiology.*—There is evidence to show that the tendency to varicose veins, particularly of the lower extremity, is hereditary. They are, however, always acquired. Long-continued standing, or standing associated with frequent action of the muscles of the leg, as in working the treadle of a lathe, and pressure upon the veins, either intra-abdominal by tumours and the pregnant

uterus, or in the limb by tight garters, are potent factors in the causation of varicose veins.

Varicose veins occur in the middle-aged and young, and are not, therefore, a sign of senility. They are commoner in women.

The right and left legs are affected equally, and about one-half of the cases are bilateral.

*Pathological anatomy.*—The gross changes which may occur in a varicose vein are increased length, tortuosity, and dilatation, especially on the proximal side of a valve, and where a deep vein joins the superficial one. The valves themselves become incompetent, chiefly owing to the fact that they do not close the dilated vein, and they may become so atrophied as to appear as mere ridges on the interior of the vein wall. As a consequence of this, in the erect position, the vein wall has to bear the whole pressure of the column of blood, and if an aperture into the lumen of the vein occurs blood will pour out from the proximal to a greater degree than from the distal part of the vein.

Fig. 101.—Excised varicose and thrombosed vein. (St. Bartholomew's Hospital Museum.)

The inner coat of the vein shows but little change, but the middle coat is often much thickened, and a similar condition, but to a lesser degree, is observable in the outer coat.

This thickening of the wall of the vein makes it less collapsible, and hence, when divided, the vein remains patent and bleeding may be profuse. The vein wall is often much thinned opposite a competent valve, and here a rupture may occur.

In many cases where the veins are varicose there is a marked want of proper return of blood from the limb, with the result that congestion and chronic inflammation of the skin occurs (varicose eczema). Irritation results, and by scratching or other injury a small wound occurs, which, becoming infected, develops into a varicose ulcer. Such an ulcer is generally seen in the lower half of the leg, is single, callous, with scanty discharge, and but little tendency to heal (see p. 39).

Inflammation of a varicose vein, leading to thrombosis, often occurs—in fact is the way of natural cure, though it is a dangerous method, since the thrombus may become detached and cause pulmonary embolism and death.

*Symptoms.*—Varicose veins of the lower limb may produce very few symptoms, but in many cases a sense of fulness and fatigue in the limb is present, particularly towards the end of a day of standing.

Œdema of the lower part of the leg and foot also occurs, together with coldness and numbness in the toes. Cramp and deep-seated pain in the calf of the leg are sometimes complained of.

*Treatment.*—The treatment of varicose veins may be palliative or operative.

(*a*) *Palliative treatment.*—(i.) Removal of the cause of varicosity is most desirable, but it can only be carried out imperfectly in most cases.

(ii.) Careful bandaging of the limb. The most efficient, and at the same time comfortable, bandage is the crêpe Velpeau. If this is unobtainable,

a domette bandage may be substituted. India-rubber bandages (Martin's) or elastic stockings should never be used. The former tend to confine all the perspiration and to aggravate any varicose eczema; and the latter are difficult to apply and soon lose their efficiency.

The method of bandaging is important. The limb should be raised first of all to allow the dilated veins to be emptied as far as possible. The bandage should then be started by taking a turn obliquely round the limb above the ankle and then one down over the dorsum of the foot, but not so as to include the heel. The bandage is now carried by wide spirals up the limb to below the knee. When this level has been reached it is brought down again in close spirals, pulled fairly tightly, until the lower third of the leg is reached, where the bandage is fastened off and secured by a safety-pin.

By this means efficient pressure upon and therefore support of the vein is secured, and there is very little tendency for the bandage to become displaced.

(*b*) *Operative treatment* is indicated where there is no evidence of thrombosis of the deep veins. As a rule ligature of the veins is the operative treatment. When there is a single enlarged vein, such as the internal saphenous, ligature is eminently successful; but when there are a number of dilated veins, particularly when the variety of varicose vessels is mixed, ligature does not by any means always lead to a successful result. In this latter condition there is a great tendency for other veins to become dilated, and to give rise to as much, if not more, trouble and inconvenience than the original vessels caused.

Ligature may be carried out in one of three ways. The first is to make multiple incisions over the prominent veins, beginning with the proximal and gradually working to the distal veins. The incision should be placed a little to one side of the vein itself and should be sufficiently long to expose about 3 inches of the vessel. After separation of the proximal part of the vein from the surrounding tissues, a fine silk ligature should be applied, and then the vein in the distal portion of the wound also should be separated and another ligature applied at this spot. The intervening portion of the dilated vein is now excised, care being taken to secure any tributaries which may be entering this portion. The wounds are sutured and a gauze bandage applied from the foot to the upper part of the thigh. In this way a considerable length of an internal saphenous vein can be removed.

A second method which is possible in other cases, particularly where there are many dilated veins over a considerable area, is exposure and ligature of the internal saphenous vein as it is about to pass through the saphenous opening. The ultimate results of this are disappointing.

In other cases, again, a combination of the two methods, namely, that of ligature of the saphenous vein in the highest part of the thigh with ligature of portions of the dilated veins distally, may in the end bring about the best results.

A third method is to make a complete circular incision of the thigh through the skin and subcutaneous tissues, divide all the venous channels on this superficial plane, and secure each by ligature.

## Angiomata.

**Angiomata** are tumours composed chiefly, if not entirely, of blood-vessels. They may form in connexion with capillaries, veins, or arteries. Those associated with capillaries are termed capillary nævi. Those connected with veins constitute venous nævi. Those connected with arteries form the cirsoid aneurysms

**Capillary nævus.**—This type may be present at birth, and is therefore congenital in many instances, although it is true that capillary nævi frequently develop within the first few weeks of life, and are therefore, strictly speaking, acquired. They appear as slightly-raised, bright red patches, varying in size from a pin's head to covering a considerable area of body surface. The two chief types may be described as follows :—1. The discrete raspberry-like tumour, which becomes almost white by the pressure of the finger causing disappearance of the blood from the vessels. As soon as this pressure is removed the sponge-like tumour fills again and regains its colour. Not infrequently these small nævi tend to increase in size, but they never spread very widely. Sometimes they become inflamed, and may ulcerate and occasionally bleed. They are frequently multiple, and appear on almost any part of the skin surface, and at times in the mucous membrane of the alimentary tract.

FIG. 102.—Venous angioma involving the outer aspect of the lower limb.

*Treatment.*—This type of capillary nævus not infrequently disappears spontaneously, so that time should be given to see whether or not it tends to diminish in size, or lose its vascularity and colour. If it shows no signs of diminution or its presence is distressing to the parents, active treatment is desirable.

The following are the chief methods of dealing with the nævus :—The first is excision, and this is probably the method of choice, because, if properly performed, it eradicates the disease and leaves a small linear scar only. Strict asepsis is requisite, and care must be taken to cut a little widely of the actual vascular area. It is astonishing what little hæmorrhage occurs, provided the vessels which feed the nævus are picked up with pressure forceps directly they are cut.

The second is the application of carbon-dioxide "snow," which causes coagulation of the blood and subsequent contraction of the blood-vessels, so that a whitish subcutaneous scar causing but little disfigurement results. Most commonly a small blister forms after the application of the "snow," and care must be taken that this does not become septic, otherwise a depressed and ugly scar will result.

The third is electrolysis, in which an electric current is run through the nævus itself, causing coagulation of the blood and shrinking of the blood-vessels.

The last is the application of radium or the X-rays.

2. The second variety of capillary nævus is that which is known as the port-wine stain, and this may affect a considerable area of skin. Such a nævus is frequently seen on the face, and may be limited to that portion of the skin

which is supplied by one or more of the three divisions of the fifth cranial nerve. The stain is darker in colour than the other type of nævus. It is very little, if at all, raised. Again, the pressure of the finger causes the disappearance of the contained blood. This form of nævus does not lend itself to very effectual *treatment*, for even the application of radium or the X-rays has very little, if any, influence upon the disfigurement. Sometimes tattooing with the galvano-cautery or repeated applications of the carbon-dioxide "snow" may bring about some improvement.

**Venous nævus.**—This variety is sometimes termed *cavernous*. It is formed by the dilatation of veins, most commonly in the subcutaneous tissue, but it is also found in such organs as the liver or the tongue, and in mucous membranes. Like the capillary nævi, they are often multiple and vary very greatly in size. They are not infrequently associated with fat, thereby constituting nævo-lipomata. Sometimes the skin over the superficial ones becomes injured and may ulcerate, with consequent hæmorrhage from the dilated blood spaces or clotting of the contained blood.

*Treatment.*—Excision is the best treatment, care being taken to cut through healthy tissue around the growth, for any incision into the nævus itself might be followed by severe bleeding. Electrolysis is useful in some cases, particularly if excision is difficult to carry out, as, for instance, in the cheek. Such electrical treatment may have to be repeated several times, under an anæsthetic, before the whole of the tumour can be dealt with.

*Nævo-lipomata* generally lend themselves to treatment by excision.

An **arterial nævus** is also termed a *plexiform angioma*, an *aneurysm by anastomosis* or a *cirsoid aneurysm*.

An aneurysm by anastomosis is congenital and usually seen in one of the extremities and characterised by large numbers of arterial and venous trunks hardly distinguishable from, and communicating with, one another. A distinct thrill and bruit are usually present. Sometimes the condition is seen in cancellous tissue of bones, and may then closely resemble an endosteal sarcoma. In some of the cases where this condition exists in the upper limb there may be a lack of proper nutrition in the peripheral parts, with chilblains, blisters, and sores resulting. This form of arterial angioma is exceedingly difficult to treat except by amputation or excision of the affected part.

Cirsoid aneurysm, again usually congenital in origin, is a collection of dilated tortuous arteries. It is seen usually on the scalp or in the orbit, being associated with the vessels that supply these parts. The perineum or lower limbs are sometimes also the seat of the condition. A well-marked bruit is always present, and there is a tendency for the tumour to increase in size. The pressure of the enlarged vessels not infrequently causes absorption of the underlying tissues and ulceration of the superficial skin.

*Treatment.*—This is by no means satisfactory. The tumour may be attacked by placing a series of ligatures upon the vessels which go to feed the aneurysm. If after ligaturing these vessels the pulsation and bruit are considerably diminished, it may be justifiable to endeavour to excise the whole growth.

## Section VI.

### THE ANATOMY AND SURGERY OF THE LYMPHATIC SYSTEM.

The Lymphatic System forms an accessory portion of the general circulatory system, and may be compared to the branch lines of a great railway which unite with the main line at various junctions; also it may be regarded as one large gland for the production of lymph.

The lymphatic system may be subdivided into :—

(A) The Lymphatics and Lymphatic Glands.

(B) The Lymphadenoid Tissue, Lacteals and Mesenteric Glands of the Intestines.

(C) The Lymphadenoid Tissue of the Respiratory Tract.

(D) The Lymphadenoid Organs, the Spleen, Bone Marrow, and Thymus.

In certain situations there are fluid systems replacing the lymphatic system, viz. :—

(*a*) The Cerebro-spinal Fluid System,

(*b*) The Aqueous Humour System in the Eye,

(*c*) The Fluid System in the Internal Ear,

which have special connexions with the venous system.

The lymphatic system serves for the return of fluid into the general circulation from the tissues, together with corpuscles to repair losses, the new red and white corpuscles being formed in the bone marrow, spleen, thymus, and embryonic lymphadenoid tissue generally. The products of digestion are largely conducted into the circulation by way of the lacteals.

Also it has protective and mechanical functions. Harmful materials are arrested or destroyed and so prevented from getting into the general circulation from the skin or from the mucous surfaces of the respiratory and alimentary tracts.

The cerebro-spinal fluid acts mechanically in protecting the central nervous system, and also serves in lieu of vasomotor action.

Lymph also acts mechanically in diminishing friction by lubricating the serous surfaces of joints, tendon sheaths and bursæ, and the large serous cavities.

The results of disease and injury manifest themselves by obstruction to the flow of lymph, by pressure on surrounding structures, by the impaired movement of serous surfaces, by the altered composition of the blood, and by septic intoxication.

The pathology of the lymphatic system has three main headings :—

1. Congenital Malformations.
2. The Invasion by Micro-organisms, and the inflammatory complications which result.
3. The Invasion by Malignant Disease.

#### The Lymphatics and Lymph Formation.

The lymphatics commence in intercellular clefts, spaces, sacs and cavities from which pass capillaries and lymphatics. They usually run in the line of

blood-vessels as vasa afferentia to lymphatic glands, and from these glands the vasa efferentia are gathered into lymphatic trunks which eventually end in the larger veins.

The lymphatic system is developed by spaces and channels in the mesoderm becoming lined by endothelium. The spaces may dilate and form lymph sacs, such as the cysterna chyli or the subarachnoid cistern under the cerebellum and medulla; lymph sacs have also been described in the cervical and gluteal regions of the human embryo, recalling those which persist in the frog and other lower animals. The lymphatic capillaries are much larger in lumen than the corresponding blood-vessels; they are formed by a regular layer of endothelium, and the larger lymphatics and lymphatic trunks resemble the veins in structure; they possess valves, and there are valves also at the junction of the lymphatic trunks with the veins.

Lymph is formed (1) by transudation from the blood, governed by the blood pressure, which is increased in inflammation; (2) by osmosis, the permeability being governed by the laws relating to the passage of substances through animal membranes, a permeability much altered by disease; (3) by endothelial activity, which selects materials from the blood, equivalent to secretion, and which is affected by chemical compounds in the blood, such as the lymphagogue substances of shellfish, and diseased products or toxins; (4) by nerve influence—non-medullated nerves are distributed to lymphatics, and some forms of œdema are referable to nerve disturbance or injury; (5) by the addition of newly-formed white blood corpuscles derived from lymph-adenoid tissue, as well as by white corpuscles which have emigrated from the blood-stream.

Lymph flows slowly towards the heart, driven on by a *vis a tergo* varying with the blood pressure, by the activity of secretion, and possibly by some contractility in the thoracic duct, which receives nerves through the first thoracic sympathetic ganglion. The flow is also influenced by circumstances outside the circulation; muscular movements, by pressing on the lymphatics in which are valves resisting regurgitation, increase the flow towards the veins, as also does massage and elevation. The flow is diminished when the part is dependent.

## Lymphatic Gland Tissue: Lymphadenoid Tissue.

Lymphadenoid tissue is a variety of connective tissue differentiated but little from embryonic connective tissue, the properties of which it has retained in various degrees. Thus it forms white and red blood corpuscles, and is concerned in fat metamorphosis, the tissue tending to become changed into fat in middle life and old age, and back again into lymphadenoid tissue under the influence of irritation and disease.

Lymphadenoid tissue appears in the thymus and around the kidneys of fish; in the liver of salamanders; in the fat bodies of frogs; but true lymphatic glands are only found in birds and mammals. In the lower mammals, such as the rodents, there are few lymphatic glands; there are more in cattle and horses, and thus they are of importance in veterinary surgery. They are most marked in man. Some appear to take an active part in the formation of red blood corpuscles, and hæmolymph glands are especially found in the sheep. There are small lymphatic glands with blood in their spaces lying along the aorta in man, but these glands are regarded as lymphatic glands retaining an embryonic structure, and the formation of red blood corpuscles in them after birth has not yet been demonstrated.

A lymphatic gland may be simple, consisting of one follicle, or compound, several follicles being enclosed in a capsule, underneath which is a peripheral lymph sinus. Afferent lymphatics enter through the capsule into the lymph sinus at many points. From the peripheral lymph sinus smaller cylindrical lymph sinuses lined by endothelium ramify in the follicles, and may be compared to the spaces in a sponge. The framework of the lymphatic gland, comparable to that of the sponge, is composed of septa of fine connective tissue continuous with the capsule, which divide into trabeculæ and ultimately into a fine reticulum. In the interstices of the reticulum, especially in the follicles, are masses of lymph corpuscles, which can pass between the endothelial cells into the lymph sinus. The ramifying lymph sinuses are collected at the hilum of the lymphatic gland into efferent lymphatics.

The arteries, *arteriæ lymph-glandulæ*, of a lymphatic gland enter at the hilum and pass by the septa and trabeculæ to form a fine capillary network in the lymph follicles, which can be demonstrated by injection to be very vascular. The capillaries end in a rich venous plexus; thence, by venules in the septa, blood leaves the lymphatic glands by *venæ lymph-glandulæ*. There is no direct communication between the blood capillaries and the lymph sinuses.

Lymphadenoid tissue is developed around a plexus of lymphatics by the collection of lymphocytes in the connective tissue strands enclosing the plexus, and the transformation of the lumina of the vessels into the peripheral and central sinuses. A lymphatic gland is a portion of lymphadenoid tissue circumscribed and enclosed by a fibrous tissue capsule. Embryonic lymphatic glands have a preponderating vascular network, in which probably red blood corpuscles are produced, and hæmolymph glands are of a persisting embryonic type.

### The Distribution of Lymphatics and Lymphatic Glands.

1. **Lymphatic glands in the groin with subsidiary popliteal glands.**—One *popliteal gland* is placed at the termination of the short saphenous vein and others deeper in the space on the popliteal vessels. Afferent lymphatics run to these glands from an area corresponding to the drainage of the external saphena vein. The popliteal glands become infected from a sore on the heel, and from osteo-myelitis and periosteal sarcoma of the leg bones. The *femoral glands* form a chain to which pass afferent lymphatics from the leg and foot corresponding to the internal saphena vein; a sore on a toe, an ulcer on the leg, or periosteal sarcoma of the femur may cause enlargement.

The *superficial inguinal glands* receive lymphatics from the external genitals, including the urethra, of the male, but excluding the testicles and cord, from the female urethra and lower vagina, the buttock, perineum and anus, also from the lower half of the abdominal wall, including the umbilicus. Hence these glands are commonly infected by venereal and malignant disease, but relatively seldom by tubercle and lymphadenoma. Also they are involved in filarial infections and plague owing to inoculation of the lower extremities and genitals.

2. **The deep inguinal and iliac glands.**—Glands on the inner side of the femoral vein, including one in the crural canal, receive the deep lymphatics from the lower limb and are hence infected by periosteal sarcoma; also efferent lymphatics from the femoral and superficial inguinal glands enter them. Along the external iliac are three glands—one on the inner side, receiving deep femoral lymphatics; an anterior gland, receiving lymphatics from the distribution of the deep epigastric artery; and an outer gland, receiving from the deep circumflex iliac area.

3. **The deep lumbar glands.**—Above the foregoing there is a chain of glands along the common iliac vessels, and on each side of the aorta and vena cava, from which pass two common lymphatic trunks to the receptaculum chyli. The glands along the iliac vessels receive lymphatics from the bladder, including the prostate and vesiculæ seminales in the male; some of these lymphatics pass through subsidiary vesical lymph-glands placed in front and to each side of the base of the bladder. In the female, subsidiary lymphatic glands, which become infected by cancer of the cervix uteri, are placed in the base of the broad ligament; thence the lymphatics pass to iliac glands. The lymphatics

FIG. 103.—Semi-diagrammatic representation of the lymphatics of the inguinal region. (After Sappey.)

from the testes and cord in the male and from the ovary in the female run to the deep lumbar glands, which also receive the lymphatics of the kidney and ureter; hence the glands become enlarged in malignant disease of these organs, but the anatomical distribution forms an obstacle to their removal.

4. **Lymphatic glands of the abdominal viscera.**—(*a*) *The stomach.*—Lymphatic glands lie along the left gastric or coronary artery and around the cardiac orifice of the stomach. They communicate with the plexus of lymphatics along the œsophagus and through them with the deep glands in the neck, especially those about the termination of the thoracic duct, and glandular infiltration occurs there in cancer of the œsophagus and cardiac end of the stomach. There is a gland just above the pylorus on the right gastric branch

of the hepatic artery. Glands lie along the course of the right gastro-epiploic artery, whence efferent lymphatics go to the subpyloric lymphatic glands. Lymphatics from the left part of the great curvature pass with the vasa brevia to the splenic lymphatics. Efferent lymphatics from these various glands go to the glands at the upper border of the pancreas and around the cœliac axis. The lymphatics from these collect to form the common intestinal trunk which enters the receptaculum chyli. Hence in cancer involving the pyloric region it is generally advisable to remove that portion of stomach supplied by the right gastric and right gastro-epiploic branches of the hepatic artery.

(*b*) *The gall-bladder and ducts.*—Lymphatics from the gall-bladder pass to a gland on the cystic duct, the cystic gland; thence lymphatics run through glands along the common bile-duct to those above the head of the pancreas.

*Lymphatics from the liver* pass to the same glands through subsidiary ones near the portal fissure and in the lesser omentum.

(*c*) *Pancreas and spleen.*—Lymphatic glands, to which afferent lymphatics come from the pancreas, spleen, and from the left of the great curvature of the stomach, lie along the course of the splenic artery and in the gastro-splenic omentum. From these, efferent lymphatics pass to the glands above the head of the pancreas.

(*d*) *Small intestine.*—The lymphatics or lacteals commence in the villi and in the lymph sinuses around the bases of the lymphadenoid nodules in the submucosa, also in lymphatic plexuses between the various coats, whence they pass out to the lymphatic glands in the mesentery. The mesenteric glands are divisible into three groups; the most peripheral are placed along the mesenteric border of the gut, also there are lymphadenoid masses in the appendices epiploicæ of the colon. An intermediate group is situated about the branching of the main divisions of the superior and inferior mesenteric arteries, and a third around the origins of these arteries and around the cœliac axis. From this proximal group of glands the efferent lymphatics, after communicating with efferent vessels from the deep lumbar glands, join the common intestinal trunk to enter the receptaculum chyli.

The glands lying along the pancreatico-duodenal and jejunal branches of the superior mesenteric artery are those chiefly concerned with digestion. The glands on the ileal branches of the superior mesenteric artery are enlarged in the course of typhoid fever and tuberculosis.

(*e*) *Large intestine.*—The *ileo-colic glands* receive lymphatics from the termination of the ileum, the cæcum, and appendix, the *right colic glands* from the ascending colon, hepatic flexure, and proximal third of the transverse colon. These glands form two chains by the side of the ileo-colic and right colic arteries respectively, which unite along the common stem of these two arteries. Hence for malignant disease in this area it becomes necessary to remove that segment of intestine with its mesentery supplied by these arteries, in order to extirpate at the same time lymphatic glands possibly infected.

The *middle colic glands* receive lymphatics from the middle and distal third of the transverse colon. The efferent lymphatics pass to the glands around the origin of the superior mesenteric artery.

The *left colic glands* receive lymphatics from the splenic flexure, the descending colon, and the proximal half of the iliac colon. They are found along the left colic artery as far as its origin from the inferior mesenteric. A division into two groups may be distinguished—those along the upper branch of the artery which supplies the splenic flexure and the neighbouring parts of the transverse and descending colon, and those along the lower branch which

supplies the lower part of the descending colon and the first part of the iliac colon.

The *sigmoid glands* are placed along the two or three divisions of the sigmoid artery which supply the distal part of the iliac and pelvic colons, and they extend up to the origin of this artery from the inferior mesenteric where the latter becomes the superior hæmorrhoidal.

(*f*) *Rectum and anal canal.*—Commencing in the longitudinal folds of mucous membrane of the anal canal (*columns of Morgagni*), the lymphatics pass upwards with the radicals of the superior hæmorrhoidal vein to pierce the muscular coat of the bowel at the junction of the rectum and anal canal. They pass through small collections of lymphoid tissue in the rectal wall, and thence drain into the pre-sacral glands situated in the fat and loose tissue behind the rectum. Efferent lymphatics carry the lymph onwards, being continually reinforced by ducts from the wall of the rectum itself, to the superior hæmorrhoidal glands lying along the corresponding vein in the base of the pelvic mesocolon. From these nodes the lymph is carried by another relay of vessels to the left lumbar and mesenteric glands. The lower part of the rectum is drained, in addition, by lymphatic vessels which pass laterally, mainly on the left side, to a few glands lying in the bifurcation of the iliac vessels and to a larger and more important set along the course of the external iliac veins. The lymph from the *anal orifice* and neighbouring parts of the buttock is collected by vessels draining into the superficial inguinal glands. These glands are enlarged by a chancre or epithelioma of the anus; the sacral and superior hæmorrhoidal glands are involved by cancer of the rectum, so that it is generally necessary to remove the rectum and pelvic colon as high as the origin of the superior hæmorrhoidal artery.

5. **Lymphatic glands of the upper extremity and breast.**—The *epitrochlear gland* lies just above the internal condyle of the humerus, internal to the basilic vein, and receives superficial lymphatics from the ulnar side of the forearm and hand. It may be enlarged in secondary syphilis.

*Subsidiary deep cubital glands*, which receive some of the lymphatics from the deep part of the hand and forearm, may be found about the termination of the brachial artery in front of the bend of the elbow. The lymphatics of the hand and forearm collect into two channels, the chief one running with the basilic vein, along which subsidiary glands may be found as well as along the deep lymphatics in the course of the brachial vessels, and then pass to the central group of axillary glands. The smaller lymphatic channel gathers lymphatics from the outer side of the forearm, arm and shoulder, and passes along the course of the cephalic vein to the infraclavicular group of glands.

The *central group of axillary glands* lies in the axillary fascia, and the glands are continuous with the infraclavicular glands and the pectoral group. Hence an affection of the fingers or hand generally causes an enlargement of the glands in the armpit, and the epitrochlear gland may swell as the result of infection on the ulnar aspect. Further, the glands may swell under the pectoral muscle, and, although this is relatively uncommon, it is important owing to the obscurity of the early signs of a subpectoral abscess and the danger of its extension. It may be explained by the infection reaching infraclavicular glands along the cephalic vein, or by infection going direct to the glands where the central axillary and pectoral groups join.

The *anterior or pectoral group of axillary glands* is placed by the side of the branches of the lateral or long thoracic artery and of the pectoral branches of the thoraco-acromial artery. Glands are found along the lower border of the pectoralis minor, between the two pectorals, and between the pectorals and

the serratus magnus. They join the central and infraclavicular groups on the inner side of the axillary vein.

The *subscapular group* is placed on the posterior wall of the axilla, on the course of the subscapular vessels, and at the lower border of the subscapularis muscle. It receives lymphatics from an area on the back of the trunk extending from the level of the umbilicus to the lower part of the neck. Boils and carbuncles in this area, or sarcoma of the scapula, may give rise to infection of these glands, as well as extensions from cancer of the breast.

The *infraclavicular group* lies between the pectoral and deltoid muscles and

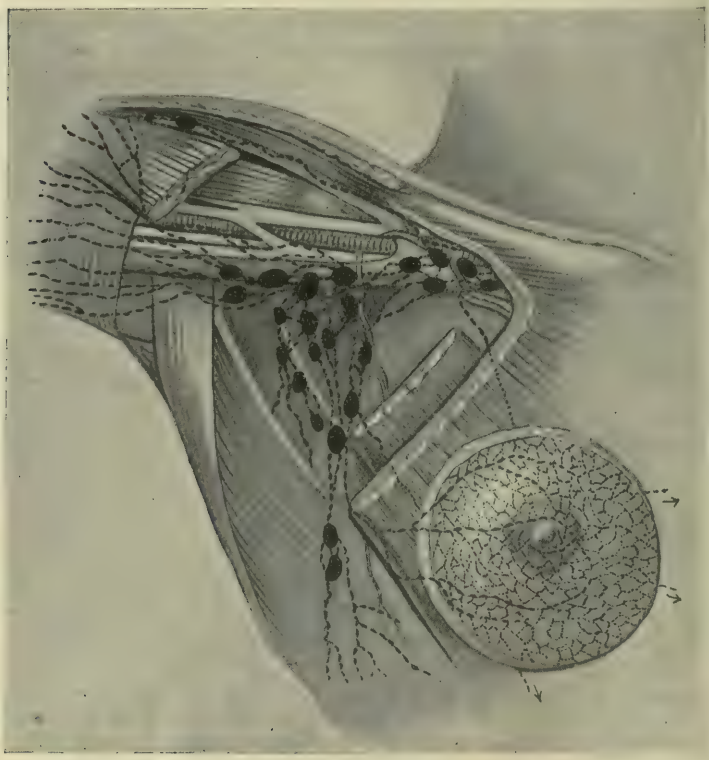


FIG. 104.—Semi-diagrammatic representation of the lymphatics of the breast, upper arm and axilla. (After Poirier and Cuneo.)

between the pectoralis minor and the clavicle on the inner side of the artery. The glands are continuous with the central, pectoral, and subscapular lymphatic glands, and afferent lymphatics also reach them direct along the cephalic vein. From them pass efferent lymphatics to the main subclavian lymphatic trunk, as well as to the deep cervical glands.

*The lymphatics of the breast.*—The lymphatics from the superficial part of the gland substance run along the milk ducts to the areola to join a plexus of lymphatics underlying the skin covering the breast. At the periphery of the gland this plexus is collected into lymphatic trunks which pierce the deep fascia and follow back the line of the branches of the long or lateral thoracic artery to the anterior or pectoral group of lymphatic glands. Many of the glands look like

masses of fat, but during lactation they develop into glands, and after lactation again undergo metamorphosis into fat. The invasion of cancer also causes the fat masses to reappear as lymphatic glands. In order to exclude cancerous infection through this subcutaneous plexus, it is necessary to remove all the skin covering the breast; and the infection of this plexus can be traced, clinically, to radiate outwards from the nipple when the cancer is of the type of "*cancer en cuirasse.*" Lymphatics also leave the breast on its deep aspect, and after penetrating the deep fascia and the pectoralis major follow back the line of the pectoral branches of the thoraco-acromial artery to the pectoral and infraclavicular glands. Some of these lymphatics may pierce the costo-coracoid membrane and go directly to the deep cervical glands. The removal of the pectorals is required to exclude the recurrence of disease in the line of these lymphatics; some lymphatics go direct to cervical glands, as shown by cases in which glands in the posterior triangle of the neck are found enlarged early in cancer of the breast.

But there are also lymphatics from the mesial border of the breast which follow the line of the perforating arteries to the *sternal lymphatic glands* lying along the internal mammary artery. Mr. Sampson Handley has traced other lymphatics as low as the angle between the seventh rib cartilage and the xiphoid appendix into the extraperitoneal tissue around the superior epigastric artery. Fortunately, early cancerous infection spreads this way in only a minority of cases.

But when cancer invades the chest wall it spreads along the lymphatics running with the intercostal vessels, which thus carry infection to the sub-pleural lymphatic plexus and to the pleural cavity.

**Lymphatic glands in the neck.**—(*a*) The *parotid and pre-auricular glands* lie superficial and also deep to the parotid fascia, and between lobules of the gland; afferent lymphatics come to them from the forehead, temple, cheek, and from the lateral part of the eyelids and conjunctiva along the course of the transverse facial artery, as well as from the anterior part of the auricle and external meatus. Outlying subsidiary glands of this group may be present below the orbit or on the buccinator or masseter muscles. The efferent lymphatics go to the deep cervical glands. These are often infected by tubercle; presumably bacilli enter through lesions on the face or eyelids.

(*b*) The *occipital glands* lie in and beneath the deep fascia over the cranial origin of the trapezius and receive lymphatics from the back of the scalp and upper part of the back of the neck, whence efferent lymphatics pass to the deep cervical glands.

(*c*) The *mastoid and post-auricular glands* lie under the deep fascia over the origin of the sterno-mastoid muscle and the mastoid process. They receive lymphatics from the parietal region of the scalp, the back of the auricle, external meatus, and middle ear.

(*d*) *The submaxillary glands.*—The glands lie under the deep fascia in close connexion with the submaxillary salivary gland, both external to and within its capsule. The afferent lymphatics to these glands correspond in the main to the distribution of the facial vein. Lymphatics from the inner part of the eyelids and conjunctiva follow the course of the angular vein. These are joined by lymphatics from the exterior of the nose and from the cheek, also by efferent lymphatics from the infraorbital and buccinator glands. An outlying submaxillary lymph gland may be placed on the facial vein where the latter becomes superficial over the jaw.

The lymphatics from the teeth of the lower jaw pass to the submaxillary glands; those from the upper jaw reach the face by way of the infraorbital

canal and then pass some to the pre-auricular glands, some to the submaxillary glands. The latter also receive lymphatics from the superficial parts of the tongue and from the floor of the mouth. They are invaded by pyogenic organisms from the teeth, by tubercle bacilli from the mouth, and in epithelioma of the tongue, etc.

(*e*) The *submental glands* lie, one on each side of the middle line below the chin, beneath the platysma, upon the mylo-hyoid between the anterior bellies of the digastric muscles. They receive lymphatics from the middle of the lower lip and skin beneath the chin, from the anterior part of the gums, floor of the mouth, and tip of the tongue. Efferent lymphatics pass to the submaxillary glands and also to the deep cervical glands at the level of the cricoid cartilage. They are infected by ulceration of the lower lip or by epithelioma in the region of the frænum.

FIG. 105.—Semi-diagrammatic representation of the lymphatics of the head, face, and upper portion of the neck. (After Sappey.)

**The lymphatics of the tongue.**—Those from the tip and anterior free part of the tongue, the frænum, and anterior part of the floor of the mouth pierce the mylo-hyoid muscle and end in the submental glands. Those from the surface of the middle of the tongue and from the floor of the mouth go to the submaxillary glands either by piercing the mylo-hyoid muscle or by passing behind it along the course of Wharton's duct. The intermuscular lymphatic plexuses unite into lymphatics, upon which may be found lymphadenoid nodules between the genio-glossi muscles and between the genio-glossi and hyoglossi. These lymphatics leave the tongue near the hyoid bone to enter the deep cervical glands.

**The lymphatics of the tonsil, fauces, and palate.**—These go to those deep cervical glands which are placed just below the angle of the jaw, behind the posterior belly of the digastric, and upon the internal jugular close to the entrance of the common facial vein. It is here that the glosso-pharyngeal nerve

in passing from between the carotid arteries across the stylo-pharyngeus muscle to the pharynx becomes involved when these glands are swollen, or infiltrated by cancer. Then pain is referred to the ear through its tympanic branch.

**The lymphatics of the naso-pharynx, maxillary antrum and spheno-maxillary region.**—These and also the lymphatics from the posterior and lateral aspects of the lower part of the pharynx turn back to the retropharyngeal or pre-vertebral glands.

**The lymphatics from the epiglottis, the pyriform fossæ, and the larynx** above the vocal cords pass out along the laryngeal branch of the superior thyroid artery, and go some to the deep cervical glands at that level, some to subsidiary glands on the crico-thyroid membrane; also subsidiary lymph glands may be found on the thyro-hyoid membrane. The enlargement of these glands may be the first sign of a cancer in the pyriform fossa.

The *vocal cords* have scarcely any lymphatics, and hence the success in excision of an early epithelioma here. The lymphatics below the vocal cords pass to glands in front of and alongside the trachea. The abundance of lymphatics from the larynx, except from the vocal cords, explains the rapid spread of extrinsic cancer.

**The lymphatics of the thyroid gland** end in the pre-laryngeal, pre-tracheal and paratracheal glands, whence efferent lymphatics lead to the lower deep cervical glands. These glands are infected early in carcinoma of the thyroid.

**The deep cervical glands** form a chain along the great vessels of the neck, partly underneath, partly in front of, and partly behind the sterno-mastoid muscle. Those in front of the sterno-mastoid in the carotid triangle commence under cover of the parotid gland, the uppermost gland being found about the origin of the internal maxillary artery. When this gland is infected by malignant disease the facial nerve may become infiltrated and paralysis set up. Also there are glands beside the posterior belly of the digastric muscle and in the pad of fat underneath the origin of the sterno-mastoid muscle in close connexion with the spinal accessory nerve. Afferent lymphatics come to these glands from the base of the skull, the orbit, temporal fossa, palate, nose, and cerebral meninges; very important glands are situated around the junction of the common facial vein with the internal jugular, to which come lymphatics from the tonsil, tongue, lips, cheek and exterior of the nose, some direct, some through the submaxillary glands. A gland immediately above the anterior belly of the omo-hyoid muscle, on the internal jugular, receives the efferent lymphatics from the submental glands.

Below the level of the omo-hyoid muscle glands are grouped around the junction of the anterior and external jugular veins with the internal jugular underneath the sterno-mastoid muscle. Lymphatics come to them from the glands above, also from those alongside the trachea and from the œsophagus.

*The deep cervical glands behind the sterno-mastoid, in the posterior triangle.*—Superficial glands which receive lymphatics from the mastoid and occipital region are found along the external jugular. The chain of deep lymphatic glands lying behind the sterno-mastoid in the posterior triangle, also known as the *glandulæ concatenatæ*, is embedded in the fascia and fat covering the roots of the cervical and upper brachial plexuses. These glands are enlarged especially in tuberculosis, syphilis, and lymphadenoma.

**The retropharyngeal glands** lie in front of the pre-vertebral muscles and receive lymphatics from the posterior wall of the pharynx, the interior of the nose and nasal sinuses, the Eustachian tube and tympanum. When infected by tubercle a retropharyngeal abscess forms in them; they become infected also by malignant disease of the upper jaw, *e.g.*, carcinoma.

**The supraclavicular glands** are continuous in the subclavian triangle with the axillary glands, and beneath the sterno-mastoid with the deep cervical glands. Efferent lymphatics unite into a jugular trunk.

**The lymphatic ducts.**—On the left side the thoracic duct unites with the left subclavian and the left internal jugular trunk to end in the left innominate vein at its commencement, or one or all three may enter the left innominate vein separately. This is at the inner border of the scalenus anticus muscle, between the left phrenic nerve and the vertebral artery externally and the left common carotid internally, whilst below are the first part of the left subclavian artery and the apex of the pleura. The right lymphatic duct, if present, is formed by the confluence of the right jugular and right subclavian trunks, with the right broncho-mediastinal trunk bringing lymph from the bronchial, mediastinal and sternal glands. The duct may be absent and the lymphatic trunks end separately in the right innominate vein at the inner border of the scalenus anticus.

The terminations of the lymphatic trunks in the right and left ducts are in contact with glands which become enlarged by extension of malignant disease from deep cervical and supraclavicular glands, and by extension upwards from the thorax, *e.g.*, in malignant disease of the œsophagus and cardiac end of the stomach; also they may be the seat of a gumma. The relations of these glands render any operative interference very hazardous.

## Injuries of Lymphatics and the Thoracic Duct.

The anastomosis between lymphatics is so free that no trouble arises from their division except where the main trunks of the limbs meet in the axilla and groin, or when the thoracic duct is injured near its termination.

**The thoracic duct** has been injured during the dissection of glands at the root of the neck. A milky fluid, chyle, escapes, either oozing up or being expelled in jets during expiration. As the thoracic duct enters the junction of the internal jugular and subclavian veins generally by a sort of delta, and also communicates with the vena azygos, as a rule the whole channel is not cut, and if a ligature is applied it does not necessarily obstruct the flow of all the chyle. For the same reason a chyle fistula tends to heal spontaneously. Thus if wounded an attempt is made to stop the flow by applying a ligature, or failing this the wound is lightly plugged with gauze. The thoracic duct has further been injured by a bullet and by a stab in the root of the neck, as shown by an escape of chyle (*chylorrhœa*).

The thoracic duct was ruptured by an injury causing a fracture of the spine; the patient died in a few days with the right pleura full of chyle.

An abdominal injury caused a rupture of the receptaculum chyli, and chylous ascites followed. A little girl fell downstairs, after which an abundance of chyle was passed in the urine (*chyluria*), but it slowly ceased and the girl was in good health several years afterwards.

**The axillary lymphatics** are injured in the extensive removal of axillary glands for mammary cancer; usually there is a sufficient anastomosis and only temporary œdema after the operation; hence marked œdema producing elephantiasis raises the question whether the collateral anastomosis is not being obstructed by an extension of the cancer.

**The inguinal lymphatics** are injured by the free removal of the femoral and inguinal glands. The dressings are freely soaked by lymph, or if the skin margins adhere they are found at the first dressing to be distended by a collection of lymph underneath. A lymph fistula persists, but, in the absence of

any recurrence of malignant disease, may be expected to heal; or solid œdema going on to elephantiasis may supervene, and there is the additional difficulty in the lower limb of counteracting gravity.

## Lymphangitis: Inflammation of the Lymphatic Spaces, Capillaries, and Trunks.

This is due to infection. Organisms in the lymphatic spaces excite the exudation of lymph; there is an increased emigration of leucocytes; the endothelial cells proliferate and act as phagocytes, and then carry off to the

FIG. 106.—Elephantiasis of the arm. Drawing of a patient taken ten years after the removal from the axilla of a carcinomatous mass which had involved a length of the axillary vein. The arm had gradually enlarged, and recently the disease had recurred in the axilla and above the clavicle.

lymphatic glands inert particles, such as carmine or the carbon particles of Indian ink used in tattooing, blood pigment, or organisms.

**Acute infective lymphangitis** may be circumscribed and tend to produce local suppuration when due to staphylococci, or spread by way of the lymphatics to the lymphatic glands with the production of inflammation there when caused by streptococci. The infection may occur through a scratch, sting, puncture, or abrasion such as a chafe on the heel.

The signs of acute lymphangitis are a local redness and œdema. A spread by the lymphatics is marked by lines of redness, due to acute inflammation of the walls of the lymphatics, which are very tender; the corresponding glands become involved. With the local signs there is generally acute fever.

The treatment consists in disinfection of the primary focus by scraping and fomentations. The spread of the infection should be restricted by a

rubber band, applied only so tight that the limb beyond remains warm, and by the dependent position of the limb ; the pain may be relieved by hot fomentations or a bath, or by painting with fresh belladonna extract in glycerin. Moreover, the spread of a streptococcal infection may be restrained by injections of antitoxin.

**Subacute or recurrent lymphangitis** is due to the persistent activity of undestroyed organisms.

**Chronic infective lymphangitis** may be due to pyogenic, tuberculous, or syphilitic infection, also to inoculation of glanders. The lymphatic trunks tend to become thickened cords ; thrombi occur at the valves, and form inflammatory nodules which break down into ulcers. A line of nodules or ulcers is then seen along the lymphatics leading up to a glandular enlargement. In proportion to the amount of lymphatic obstruction there are patches of chronic œdema. The diagnosis turns chiefly upon the identification of the infecting organism. The treatment generally consists in counteracting the organism ; locally, ulcers may be scraped and thickened lymphatics excised.

**Obstructive lymphangitis** leads to distension and leakage from the peripheral lymphatics. The cutaneous lymph spaces dilate into vesicles, which rupture through the epidermis ; lymph escapes (*lymphorrhœa*), and may dry into irritating crusts, exciting eczema and ulceration, or the flow may persist as a lymph fistula. The distension of subcutaneous lymph spaces causes chronic œdema and ulceration. Upon this follows a gradual increase of the subdermal and subcutaneous fibrous tissue, and the surface of the skin becomes rugose (*elephantiasis*). Effusions occur into serous cavities causing ascites or hydrocele ; obstruction in the course of the lacteals causes a chylous effusion into the peritoneal cavity (*chylous ascites*), into the tunica vaginalis (*chylous hydrocele*), into the urinary tract (*chyluria*), or upon the surface (*chylorrhœa*).

Obstructive lymphangitis and its sequelæ are set up by contractures after burns or other injuries : they supervene upon chronic ulceration of the leg ; and are caused in particular by filarial infection and leprosy.

Obstructive lymphangitis is treated by checking the cause of the inflammation and favouring the flow of lymph towards the veins by hot applications, elevation, bandaging and massage, multiple punctures and drainage. In addition, the following surgical methods are under trial :—(*a*) anastomosis between an obstructed lymphatic trunk and a vein, *e.g.*, between a distended lymphatic channel in the groin and an epigastric vein (Godlee and Manson) ; (*b*) epiplopexy, for ascites (Drummond and Morison) ; and (*c*) running strands of silk along the subcutaneous tissue from the distal to the proximal side of the obstruction (Sampson Handley).

## Lymphatic Malformations.

**Congenital lymphangiectasis** is a dilatation of subcutaneous and inter muscular lymphatic spaces which may be traced to a failure of the normal communication between lymphatic trunks and the large veins.

A circumscribed patch on the skin or tongue forms a *lymphangioma*, or *lymphatic nævus*, when in the subcutaneous tissue a fibro-cystic tumour, or *hygroma*. If the main lymphatics of a limb are obstructed, *elephantiasis* results. A dilatation of the lymphatics of the spermatic cord (*diffuse hydrocele of the cord*) and a bunch of dilated lymphatics in the subcutaneous tissue, *lymphocele*, are rare conditions resembling the parallel conditions in veins.

**A lymphatic nævus** occurs on the tongue, lips, or skin as a strawberry-like elevation studded with little cysts, about the size of mustard seeds ; some of

the cysts contain clear yellow fluid; into others project bright red capillary loops; some of the swellings are blue from the cyst being filled with extravasated blood. Between the cysts is a vascular connective tissue. The cysts rupture and discharge lymph, which may dry on the surface. Beneath the surface it may be continuous with a cystic lymphangioma.

**Lymphangioma hypertrophicum or lymphatic wart** is a soft, red, lobulated flat wart on the skin, which is composed of endothelial cells ranged somewhat in columns vertical to the surface and covered merely by the epidermis; some are combined with hair follicles and melanin pigment to form hairy

FIG. 107.—Congenital cystic lymphangioma or hygroma of neck. (St. Bartholomew's Hospital Museum.)

and black moles. They may persist through life unaltered; on the other hand, after irritation they may become the seat of endothelioma or melanotic sarcoma.

**Lymphangioma cavernosum vel cystoides** is a mass, circumscribed or diffused, of dilated lymphatic spaces in the subcutaneous and inter-muscular connective tissue. The lymphangioma on section may present a honeycomb-like appearance, or the spaces become dilated into cysts of varying dimensions which contain lymph or extravasated blood. The interstitial tissue is a very vascular, soft, œdematous or almost myxomatous fibrous tissue, containing groups of small round cells or masses of lymphadenoid tissue. Perhaps lymphangioma may be explained as a persistence of embryonic lymph spaces and sacs. In the lip a diffuse lymphangioma is called *macrocheilia;* in the tongue, *macroglossia;* in the neck, and less commonly in the renal or inguinal region, *hygroma;* in the limb, *elephantiasis.*

Lymphangiomata are liable to recurring attacks of inflammation, with

local swelling and general fever; occasionally an attack of inflammation has been followed by disappearance; generally, each attack increases the lymphangioma. An important deformity is set up, or, the lymphatic spaces rupturing, the lymphangioma is infected and suppurates. As congenital obstructions they are liable to become the seat of malignant disease, usually a small round-celled sarcoma, or endothelioma.

*Treatment.*—Excision whenever practicable; failing this, the repeated injection of iodine and absolute alcohol.

## Lymphadenitis: Lymphatic Gland Inflammation.

Inorganic materials, such as carmine, the carbon particles of Indian ink used in tattooing, and soot particles inhaled by the lungs, are carried by the lymphatics to the lymphatic glands and are there arrested in the peripheral or central lymph sinuses; they become engulfed by phagocytes and surrounded by connective tissue. Dead and diseased products, and organisms arrested in these sinuses are digested and destroyed by phagocytes. The result upon the gland may be a temporarily increased vascularity, causing the gland for the time being to become swollen and tender.

If the irritation is prolonged the gland becomes indurated from an increase of fibrous tissue in the capsule and septa, with a corresponding diminution in the lymphadenoid tissue. Also prolonged irritation may cause lymphadenoid tissue which has become metamorphosed into fat to resume its lymphadenoid structure. Hence lymphatic gland tissue may be found in unusual places, or in larger amount than normal, or lymphatic glands may appear more numerous than ordinary, as in the axilla in cases of carcinoma of the breast.

The infective organisms having reached the lymphatic glands, may there become latent. In filarial disease the organisms collect in lymphatic glands, block the efferent lymphatics, and cause dilatation of the lymph sinuses (*lymphadenocele*), with liability to recurring attacks of inflammation and extension of the disease. Tubercle bacilli are imperfectly destroyed; they collect in lymphatic glands, and may remain for a long while latent; then a sort of explosion occurs and there is rapid spreading. To such latency of organisms in lymphadenoid tissue may be traced the so-called cryptogenic invasions, the relapses and recurring attacks of tonsillitis, typhoid fever, appendicitis, and of inflammations of the spleen.

We must recognise that lymphadenoid tissue is no very complete bar to infection reaching the circulation. Anatomical injections of lymphatics demonstrate a very free anastomosis between lymphatics as well as free communication with veins, but it is probable that the injections are made under a pressure greater than that obtaining in infections of the milder sort.

Diseased particles, micro-organisms, and cells may pass directly by lymphatics into veins, especially in the regions of the groin, axilla, head and neck, or even through lymphatic glands, without being arrested, just as fat during digestion passes through the mesenteric glands.

**Lymphadenitis, acute, subacute or chronic,** may usually be traced to peripheral infection through the afferent lymphatics, or to some general microbic infection; occasionally inflammation of the glands in the groin or axilla has been attributed to a strain, as in lifting heavy weights, or to an excessively long walk. Such cases, in the absence of all causes of infection or irritation, have been ascribed to an excess of lymph being pumped into the glands from the muscular interspaces, or to obscure blood extravasations.

In acute inflammation the lymphatic gland becomes rapidly enlarged, partly by vascular dilatation, partly by distension of the lymph sinuses with lymph crowded with cells, amongst which are collections of the micro-organisms causing the lesion. The swollen lymphatic gland presents the signs of inflammation; at first it may be movable, but in acute cases is soon fixed by the inflammation spreading out from the gland (*perilymphadenitis*), which tends to fuse a packet of lymphatic glands into a single mass.

When the circulation continues through the gland the infective organisms may be destroyed, the fluid absorbed, and the gland after a time return to the normal. A common instance of this is the acute inflammation of the glands in the neck. If the circulation through the glands becomes obstructed necrosis and suppuration follow. Suppuration in such a case may be limited to one or more glands of a series, or, if not treated early, the suppuration may extend until the whole mass of glands is fused into one abscess containing sloughs of the connective tissue frame-work of the glands. Familiar examples of suppurating lymphadenitis are seen in the bubo of gonorrhœa and soft sore, and in the suppuration under the jaw caused by a carious tooth. Hæmorrhage complicates suppuration in virulent infections such as phagedena, and is the characteristic feature of plague buboes.

The *treatment* of acute lymphadenitis consists in treating the site of infection, in applying hot fomentations, and in keeping the part at rest. If suppuration in a superficial gland appears imminent the skin may be frozen and a puncture made with a knife. If suppuration has actually set in a free incision should be made under nitrous oxide anæsthesia and the abscess thoroughly drained.

**Subacute lymphadenitis** may result from the same causes as the acute; also it is a feature of various specific fevers, *e.g.*, the glands at the nape of the neck in German measles.

**Chronic lymphadenitis** is most frequently due to tuberculous or syphilitic infection.

A subacute and chronic lymphadenitis is *treated* by rest and by pressure gently applied by a pad and bandage.

**Syphilitic lymphadenitis** occurs:—1. In the glands receiving lymphatics from the site of the primary sore. In the inguinal region the glands are enlarged, hard, relatively painless, and remain discrete without any perilymphadenitis so long as there is no mixed infection. In the case of extragenital chancres the enlarged glands may be united into a mass by œdema, as in the case of the glands under the jaw following a chancre on the lip. Under antisyphilitic treatment all swelling may rapidly disappear; if the infection is virulent or the treatment inadequate, the glands continue to form an indolent enlargement and subsequently undergo gummatous degeneration and suppuration.

2. During the secondary stage of syphilis there occurs a general chronic enlargement of lymphatic glands, the glands at the back of the neck being particularly affected. Such glands may undergo fibrosis and the enlargement persist.

3. Glands enlarged in the course of primary or secondary syphilis, in which the inflammation has not resolved owing to inadequate treatment, may become the seat of a gumma. Unless subsidence takes place quickly under antisyphilitic measures an incision should be made and the gumma scraped away.

**Tuberculous lymphadenitis.**—*Pathology.*—A localised tuberculous lymphadenitis most commonly occurs in the cervical glands of children, the

tubercle bacillus gaining entrance through the mouth and pharynx; also in the mesenteric glands from the intestines. The tubercle bacillus may be inoculated through the skin, and, exceptionally, through a wound, as after circumcision. A preliminary lesion may admit the tubercle bacillus only, or pyogenic organisms also, as, for instance, in cases of pediculi on the head, eczematous cracks about the mouth, carious teeth, enlarged tonsils and adenoids, and sores on the foot: widespread infection of the glands may accompany general tuberculosis. The lymphatic glands slowly enlarge; tubercle bacilli in the lymph follicles set up endothelial proliferation and small-celled infiltration. Generally when a swollen gland is cut across, tubercles—non-vascular areas composed of small round cells and containing giant cells and tubercle bacilli—are seen in the follicles. Caseation commences in the centre and spreads outwards. The gland appears studded with separate foci of caseation; when these have fused together the gland capsule is distended by curdy pus. Meanwhile perilymphadenitis tends to fuse the separately enlarged glands together and suppuration spreads beyond the gland capsules. But tuberculous lymphadenitis may stop short of caseation; then there may be complete absorption, or fibrosis rendering the gland hard. In the latter case, if tubercle bacilli remain latent in the gland, recurring inflammation and a residual abscess may arise later. After undergoing caseation the fluid may become absorbed and the glands become cretaceous and opaque to X-rays.

Sometimes tuberculous lymphadenitis takes the form of a diffuse endothelial proliferation of the whole gland instead of tuberculous foci in the lymphadenoid follicles; caseation and suppuration are long delayed; on section the naked-eye appearance resembles that of a potato. The disease is then very difficult to distinguish from lymphadenoma, and as tubercle bacilli are hard to find, the diagnosis may only be made by inoculating guinea-pigs.

*Signs.*—As the glands enlarge there is pain and tenderness, varying with the acuteness of the inflammation; if the enlargement is slow there may be no complaint of pain. The enlarged glands are at first distinct and movable; when they gradually become fixed and the separate glands coalesce, caseation and suppuration is indicated.

If neglected, the skin becomes red and adherent to the softening glands, gives way, and curdy pus escapes. There is thus set up a tuberculous ulcer with bluish-pink, undermined edges, the floor being formed by the caseating gland; or there is a sinus leading down to a suppurating focus, the tuberculous inflammation being complicated by the entrance of staphylococci and bacillus pyocyaneus. Such ulcers may continue indolent, and if they ultimately heal, there remain raised, puckered, pinkish-white scars.

Neglected tuberculous glands may become the focus for the dissemination of a general tuberculosis; or suppuration may induce a general septic infection and, if prolonged, amyloid disease.

*Treatment.*—The source of local infection being removed, the lymphadenitis may subside spontaneously—or the inflammation may slowly disappear under the general treatment for tuberculosis, sea-air and sunlight being the remedies most firmly established. Until caseation and suppuration threaten, surgical interference may generally be delayed; but immediate treatment is called for when the enlarged glands begin to soften, lest suppuration spread to the skin or surrounding tissues. If the glands are discrete and no deep glands enlarged, a short incision in the lines of the folds of the skin should be made over each, the interior scraped out and iodoform inserted. If the inflamed glands are fused together, a complete dissection of the whole mass should be undertaken.

An indolent ulcer or a chronic sinus should be excised with the underlying enlarged glands.

## The Spread of Malignant Diseases by the Lymphatics and Lymphatic Glands.

(*a*) **Small-celled infiltration.**—The earliest change noticeable in the lymphatic system is a collection of small round cells in the lymphatic spaces immediately beyond the growing margin of the malignant disease; small round cells are found also in the lumen of, and around, the lymphatics leading away from the growth, and similar cells come to fill the lymph sinuses of the corresponding lymphatic glands. These small round cells appear to be the result of inflammation excited by toxins derived from the malignant growth. Possibly some of the cells, at first indistinguishable from inflammatory cells, are really young cells derived from the malignant growth, and capable of transferring the disease and setting up a metastatic focus. The majority are descendants of endothelial and connective-tissue cells, capable of acting as phagocytes in removing the products of degeneration, or of serving as fibroblasts which wall off the disease as if it were a foreign body.

Malignant disease with ulceration on the surface is followed by a pyogenic infection extending to the lymphatic glands.

(*b*) **The extension of the cells of malignant disease.**—1. Cells detached from the new growth pass by the afferent lymphatics to the corresponding lymphatic glands, where they lodge in the peripheral and other lymph sinuses and originate a secondary focus of the same disease. After involving the gland, the disease spreads further through the capsule to the connective tissue around and unites with neighbouring glands, similarly affected, to form a secondary malignant mass. This secondary extension of malignant disease is also associated with a zone of small-celled infiltration concerning which the same question arises as in connexion with the primary growth, viz., as to whether at its commencement the small-celled infiltration is purely an inflammation, or mixed, as it is certainly later, by an invasion of malignant cells.

But the cells detached from a malignant new growth may not be arrested in the lymphatic glands of the area; the cells may pass through and so reach the veins, or break directly into veins, and so give rise to metastatic growth without any preliminary invasion of lymphatic glands.

2. Malignant disease may spread by direct continuity to lymphatic spaces, radiating out from the primary focus in all directions. Or it may extend by continuity along lymphatics which become blocked by the new growth, either along the lumen or along the lymphatic walls and the perilymphatic spaces. Cords and nodules may thus be felt in superficial lymphatics, as, for instance, over the breast in *cancer en cuirasse*, or on the dorsum of the penis as the result of epithelioma of the prepuce. As in the primary growth itself, a fibrosis may occur in the extension along the lymphatics, the meaning of which is doubtful. Is the fibrosis produced by fibroblasts derived from connective tissue and endothelial cells of the original normal tissues? Is this fibrosis directed to the walling off of the new growth, or does the inflammation, by increasing the vascularity, increase the rapidity of the invasion of the malignant disease cells?

From the surgeon's point of view small-celled infiltration and fibrosis must be treated as part of the malignant disease, as is plainly shown in connection with epithelioma of the tongue or scirrhus of the breast. Even in cases of a

limited degree of malignancy, such as rodent ulcer or atrophic scirrhus, the difference lies in the cells of the original growth, and not in the amount of small-celled infiltration or fibrosis.

## Lymphadenoma.

This is an enlargement of lymphatic glands which commonly commences in the glands of the posterior triangle of the neck, less often in those of the axilla or groin. It is supposed to be set up by microbic infection, but the actual organism has not yet been identified. Local irritation in the conjunctiva, naso-pharynx, mouth, hand, or genital organs has been followed by a lymphadenomatous growth in the corresponding glands. It is characterised by progressive enlargement of the several lymphatic glands, which remain limited by their capsules and discrete, connected by perilymph-adenoid fibrous tissue into a doughy mass. On section the enlarged gland appears to differ little from the normal, except that the cut surface appears homogeneous and whitish in appearance, the distinction between the cortex and medullary portions has become lost, and the gland substance is tougher than normal. On microscopical examination the enlargement is found to be due to a proliferation of endothelial cells lining the lymph sinuses and covering the reticulum; these cells may become large and contain more than one nucleus. The lymphocytes are decreased in number, whilst the connective-tissue framework of the gland increases with the duration of the disease. In acute cases there is a marked increase of eosinophile cells. The foregoing distinguishes lymphadenoma from simple inflammatory enlargement, from small round-celled sarcoma, and from tuberculosis even in the absence of tubercles or of any tendency to suppuration and caseation. The course of lymphadenoma varies; an indolent enlargement of glands on one or both sides, whether in the posterior triangle of the neck, axilla, groin, or elsewhere, may continue for a year or two or longer before there is generalisation. An acute case may run its course within six months. In a very slow case there are at first no general symptoms—in particular, no change in the blood; later anæmia shows itself. The more acute cases are accompanied by fever, some of a relapsing type; others show a hectic type, and chills and rigors may suggest suppuration. As the disease becomes generalised the superficial glands become more widely involved. In the thorax, lymphadenomatous masses develop in the positions of the thymus and mediastinum; in the abdomen, the spleen, which on section appears studded with whitish masses, less often the

FIG. 108.—Mass of lymph-adenomatous lymphatic glands. The larger ones are seen in section. (St. Bartholomew's Hospital Museum.)

liver and mesenteric peritoneal glands, become involved, and death is due to pressure.

Lymphadenoma must be distinguished from enlargement due to simple or septic inflammation, tuberculosis, and syphilis. It is distinguished from leucocythæmia with enlargement of lymphatic glands by examination of the blood. It is difficult to distinguish lymphadenoma from the diffuse endothelial infiltration of glands by tubercle except by animal inoculations. Also lymphadenoma may be complicated by tuberculosis. Small round-celled sarcoma may closely simulate lymphadenoma, and may only be distinguished on the excision of a gland for microscopic examination.

*Treatment.*—The excision of all enlarged glands whenever practicable. In widespread disease neosalvarsan given intravenously often causes a temporary diminution, and this subsidence may afford an opportunity for an excision, previously impossible, of the glands in which the disease started; if this is not done the enlargement usually recurs. Exposure to X-rays causes a marked diminution, but for a time only; great care must be taken not to create a burn.

FIG. 109.—Lymphadenoma of the spleen ("hard-bake" spleen). (St. Bartholomew's Hospital Museum.)

## Small Round-celled Sarcoma.

Sarcoma commences in lymphadenoid tissue, in the cervical, axillary and inguinal lymphatic glands, in the faucial, lingual, or pharyngeal tonsils, in the position of the thymus, in the spleen, or in the scattered lymphadenoid masses found in subcutaneous tissue.

The disease is marked by a steady non-inflammatory enlargement Complications follow, such as an extension from the neck to the mediastinum.

*Treatment.*—Immediate excision whenever practicable. In a few instances most marked effects have followed the application of X-rays and radium.

# Section VII.

## SURGERY OF THE NERVES.

**Structure of a nerve.**—Whether medullated or non-medullated, the essential part of a nerve is its axis-cylinder. In the *medullated* variety the axis-cylinder is surrounded and protected by the medullary sheath, a semi-fluid medium of fatty nature, interrupted at regular intervals (the nodes of Ranvier). Both axis-cylinder and medullary sheath are further enclosed by the neurilemma or sheath of Schwann. The latter dips in at regular intervals at each node of Ranvier, so as to come into close relationship with the axis-cylinder itself. Beneath the neurilemma, in each internode, there is an oval nucleus, the neurilemma cell. In *non-medullated fibres* the axis-cylinder is protected by the neurilemma only, this sheath possessing nuclei as before but of a smaller type.

**Changes in a nerve after complete division.**—After complete division of a nerve the two ends, though retracting slightly within their sheaths, are more or less glued together by the blood effused at the site of the lesion. This blood-clot, together with innumerable young axis-cylinders budding out from the proximal end and the scar tissue developing from the inflammatory exudate, all combine to form a *bulbous nodule* at the site at which the nerve was divided.

Both proximal and distal ends degenerate, the proximal only up to the nearest node of Ranvier, the distal right up to the termination of the nerve in skin, muscle, etc.

This degeneration begins within a few days of the occurrence of the injury, and at the end of a few weeks the following *microscopical changes* are to be seen:—Disintegration of the axis-cylinders and their final disappearance; breaking up of the medullary sheath into fat globules; and proliferation of the neurilemma cells. Finally, it will be found that the main sheath of the nerve consists of nothing more than a mass of degenerated nerve tissue totally incapable of transmitting nerve impulses. These products of degeneration are absorbed in the course of time and little remains but a shrunken fibrous cord. This final process is complete within a few months from the date of the injury if no attempt, or if an unsuccessful endeavour, be made to bring about a satisfactory anastomosis of the two ends of the nerve trunk.

**The effect produced by the complete division of a nerve on the tissue supplied by that nerve.**—In the event of complete division of an ordinary mixed nerve, for example the median, the tissues are affected in the following manner:—

1. The *muscles* deriving their sole innervation from the nerve involved at once become paralysed. They soon commence to waste and become flabby. Microscopically these changes are seen to be due to fatty degeneration, and, in the absence of successful nerve reunion, the muscle fibres become converted into a mass of fibrous tissue and fat. This change is gradual in its development, the ultimate stage of complete degeneration requiring a year or more to reach its final consummation. So long as only scattered islands of fat

are seen, regeneration is possible, if the muscle is again reconnected with its nerve supply. Contractions are liable to take place as the direct result of the unopposed action of the antagonistic group of muscles, and if this is allowed to persist and progress considerable deformity will ultimately result.

The *electrical reactions* require careful consideration.* When a motor nerve is divided the paralysis of the muscle supplied is quickly followed by a change in its electrical reactions. The electrical reactions of a muscle are the contractions that follow stimulation by two forms of current,—first that given by an induction coil (the interrupted or *faradic* current), then that given by a battery of cells (the continuous or *galvanic* current).

To test the reactions we require, besides the battery and coil, two cables to conduct the current to the body; two electrodes, one to lead the current *into* the body (the anode), the other to lead it *out* of the body (the kathode); and a key, whereby the circuit may be completed or interrupted at will.

One electrode is placed on the muscle in the region of its motor point, *i.e.*, the point of entry of the motor nerve. It is a padded metal disc, $\frac{3}{4}$ inch in diameter, with a handle screwed into it. It is known as the "testing electrode," and the key is usually fixed to its handle. The other electrode is placed on some other part of the body, away from the muscles to be tested. It is a flexible padded metal plate measuring 4 by 6 inches. Both pads and the skin in contact should be moistened with salt solution.

Before commencing the test the current should be regulated by a preliminary trial on the thenar muscles of the observer, so that it is just strong enough to produce a well-marked contraction. The interrupted current, which is applied first, produces, on the normal subject, a tetanic contraction which lasts while the current flows. The continuous current, which is applied next, produces only a single twitch. It occurs at the moment the circuit is completed. No contraction occurs while the current flows, and none occurs (if the current be not excessive) at the moment the circuit is interrupted. A stronger twitch occurs if the testing electrode is the kathode. This electrode should always be the kathode, as will be the case if it is connected with the negative pole of the battery. These reactions—a tetanic contraction following stimulation by the interrupted current and a quick twitch following stimulation by the continuous current—are known as the "normal reactions," and they are obtained whether the stimulus is applied to the muscle or to its motor nerve.

When the motor nerve is divided the reactions soon change. The only current that can now produce any contraction is the continuous current, and only when it is applied to the muscle itself. The contraction differs from the quick twitch given by the normal muscle in that it is slow or "sluggish." It is more readily obtained when the electrode is placed on the distal end of the muscle away from its motor point.

The interrupted current can produce no contraction, whether applied to the motor nerve or to the muscle itself. This reaction—a sluggish contraction of the muscle when stimulated by the continuous current, with no response to either current when applied to the motor nerve, or to the interrupted current when applied to the muscle—is known as the *reaction of degeneration*. It signifies that there is a lesion somewhere in the lower motor neurone and that the nerve below the lesion has lost its excitability and conductivity. It was mentioned earlier, when referring to normal muscles, that the galvanic current caused a contraction at the moment when the circuit was completed or "closed," and that the contraction was stronger when the testing electrode was the *kathode;* in other words, the "kathodic closure contraction" (K.C.C.)

* From information kindly supplied by Dr. E. P. Cumberbatch.

was greater than the " anodic closure contraction " (A.C.C.). When a muscle shows the reaction of degeneration it is *sometimes* found that the converse is true. This " polar reversal " as it is called, where the A.C.C. is greater than the K.C.C., only occasionally occurs, and is not an essential feature of the reaction of degeneration, as was formerly supposed.

After section of the motor nerve the muscle ceases to respond to the interrupted current in from four to seven days, while the sluggish contraction appears about the tenth day. In course of time it grows progressively feebler, but it may persist for some years before it finally disappears.

2. The *skin* supplied by the nerve immediately becomes anæsthetic, the various senses being affected in the following manner: —there is a well-defined area showing loss of *epicritic sensibility* or sensibility to light touch, such as is supplied by testing with cotton-wool. The area of anæsthesia is rather less than might be anticipated according to the anatomical distribution of the nerve, this being due to the overlapping of the areas supplied by neighbouring sensory nerves. In the area supplied both by the injured and neighbouring uninjured nerves, sensation is dulled without being actually destroyed.

A rather smaller area shows loss of *protopathic sensibility* or sensibility to pain, heat and cold. *Deep sensation* is conveyed along the nerves supplying the muscles and along the tendons, and consequently it is but little impaired so long as the muscles and tendons are not included in the injury.

3. *Trophic changes.*—The skin becomes glossy, the nails brittle, striated and heaped up at the edges (keratosis), and the hair shows irregularities of growth and more rarely of colour also, added to which the hairs tend to break freely away at their roots. Blisters, ulcers of an indolent type, and whitlows are prone to develop, partly on account of the diminished vitality of the part and partly by reason of the inability on the part of the patient to appreciate heat, cold, etc. Such ulcers are invariably difficult to treat and slow to heal.

4. *Vaso-motor changes.*—The skin appears blue and mottled, congested, even œdematous (angio-neurotic œdema). The temperature of the part is lowered and the patient complains bitterly of the cold, the fingers going blue and even white on slight provocation. Gangrene of a portion of a finger may result after excessive exposure to cold.

5. *Joint and bone changes.*—In some few cases definite joint changes may occur—fibrous ankylosis, mainly due to extra-articular changes, osteoarthritis, etc. The bones are also said to become more brittle.

**Regeneration of the nerve.**—The regeneration of the nerve is dependent on downward growth of new axis-cylinders from the proximal end of the nerve. They enter the distal nerve sheaths and later on acquire a myelin coating, the neurilemma cells proliferating at the same time and aiding in the formation of the connective-tissue framework. These new axis-cylinders are developed in large numbers, considerably in excess of actual requirements; but many are lost by the way, wandering aside, impeded in their course and strangulated by the young fibrous tissue. In addition, any suppuration, gap between the two ends of the nerve, intervention of foreign body, or premature use of the limb to which the nerve belongs will interfere proportionately with successful downward growth of the developing axis-cylinders. It is obvious, therefore, that, even under the most favourable circumstances, a complete recovery of all tissues supplied is rather problematical.

**Regeneration of the tissues.**—The tissues supplied by the nerve will recover in direct proportion to the time at which the nerve union is effected and the accuracy and cleanliness with which the operation can be conducted.

The first sign of true regeneration is supplied by the return of *protopathic* sensation, the area previously insensitive to pain, heat and cold, slowly but steadily diminishing in size—concentrically. This sign of recovery is not likely to become evident under two to four months from the date at which the nerve ends were united. About one to two months later the area of skin showing loss of *epicritic* sensibility begins in turn to diminish in size. It is true that some "*recurrent sensibility*" may be appreciated in the area previously insensitive to touch within a few days of the nerve union, but this shortly disappears again, not to return till true regeneration of nerve fibres takes place.

An absolute recovery of both protopathic and epicritic sensibility is seldom observed, though the tissues recover sufficiently for all practical purposes.

Recovery of *motor power* is the last of the functions to be restored, definite improvement in muscular power seldom being observed under a period of six months, and in many cases a much longer period is required—one year or more. In addition, it may be stated that recovery of motor power is almost invariably less complete than that of sensation. The after treatment by massage and electricity (see p. 357) also exercises a great influence on the rapidity with which motor functions reassert themselves and on the degree to which the muscles finally respond to the nerve impulses.

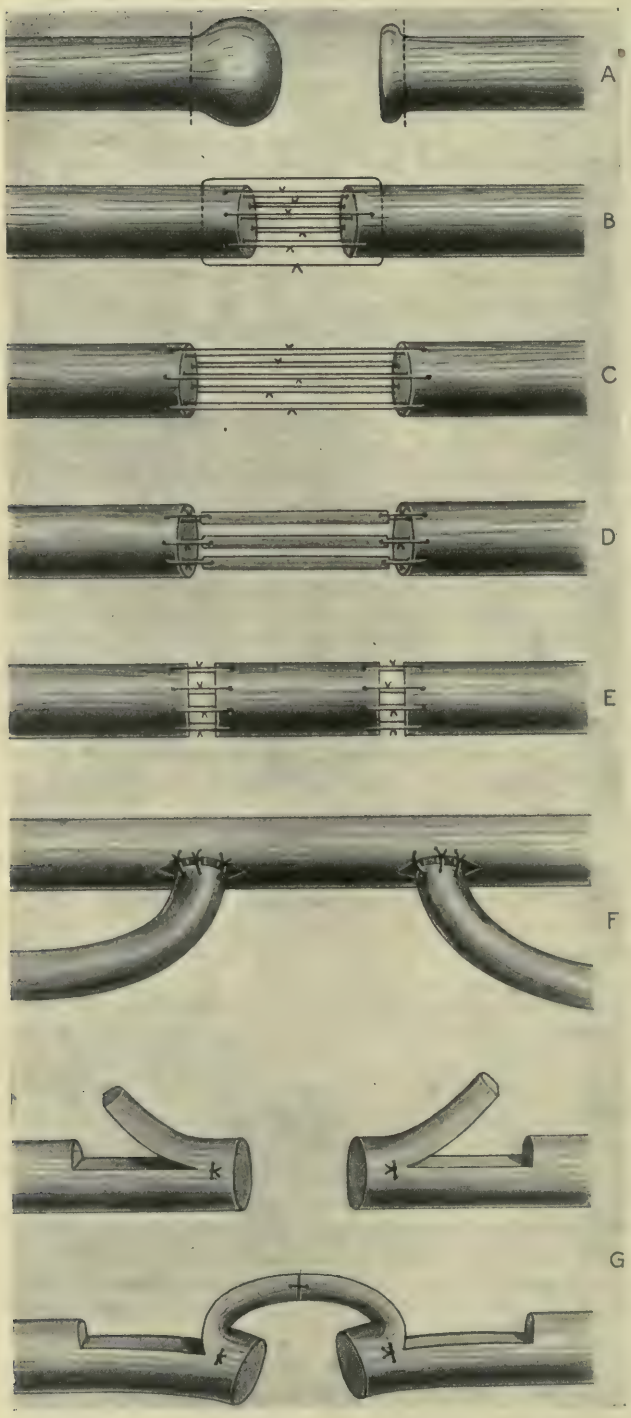
**Treatment of a divided nerve.**—It may be laid down as a primary rûle that a divided nerve, whether motor, sensory or mixed—provided that it is of such importance as to merit any treatment at all—should be reunited as soon as possible. *Primary* union offers far better results than *secondary* anastomosis. There are only two reasons for delay—in the event of doubt as to the extent of the lesion and in the presence of local suppuration. In both these instances it is justifiable to await events, more especially in the second instance, where any attempt at immediate union would almost necessarily terminate in failure. Here it is advisable to await the healing of the wound, and then to carry out secondary suture.

The following methods of anastomosis are available (see Fig. 110) :—

1. Direct end-to-end anastomosis.
2. Indirect end-to-end anastomosis.
3. Transplantation.
4. Flap operations.
5. Implantation.

It may be stated definitely that there is no comparison between these methods. Experience shows that there is only one method—end-to-end union. All attention, therefore, must be directed towards that end. Recently it has been shown that, even when the two ends of the divided nerve cannot be brought together at the time of exploration, success may be attained at a second effort by adopting the following procedure, this being explained best by taking a specific case. There is a gap between the two ends of the musculo-spiral nerve, even when the forearm is fully flexed. If the ends of the nerve be tied tightly together with catgut, and if the forearm be gradually brought down straight, the continual pressure exerted on the upper and lower ends of the nerve may suffice to stretch them so that at the second exploration it may be found possible to unite them in the desired fashion.

*Direct end-to-end anastomosis.*—The injured nerve is exposed by clean dissection in a bloodless field. The ragged ends are refreshed with a sharp scalpel, the useless portion being shaved away at right angles to the nerve trunk. In the presence of bulbous ends the node must be cut away, more




A. The dotted lines indicate the level of the "refreshing" of the nerve ends. The larger node is on the proximal side.

B. Direct end-to-end anastomosis—tension and fixation sutures.

C. Indirect end-to-end anastomosis—trellis-work method.

D. Bridging over a gap in the course of a divided nerve by means of several small portions derived from the long internal saphenous or other sensory nerve.

E. Bridging over a gap in the course of a divided nerve by means of nerve material obtained from an animal.

F. The implantation of the two ends of a divided nerve into the lateral aspect of a neighbouring sound nerve.

G. The union of a divided nerve by means of flap formation.

FIG. 110.—To illustrate the various modes of nerve anastomosis.

tissue being removed from the proximal than the distal end. The ends are sutured to one another by a single *tension* suture (of the finest silk) passed through the whole thickness of the nerve about ½ inch distant from the free ends, and by a few *coaptation* sutures which pick up the sheath of the nerve only and bring about accurate apposition. During this process it is necessary to avoid pinching the nerve with forceps, as such a procedure tends to destroy more axis-cylinders. The sutured ends may be painted over with collodion to aid in the prevention of invasion by developing fibrous tissue. The wound is then sewn up and the limb fixed in the required position, all tension being avoided. Thus, after union of the median nerve at the wrist the hand is fastened to a splint fully flexed and maintained in that position for ten days. The stitches are then removed and the hand gradually brought down to the normal position.

Other forms of anastomosis are occasionally necessary. For instance, the distal end of a facial nerve, injured beyond repair in the aqueductus Fallopii, can be dissected out and implanted into the lateral aspect of the hypo-glossal or spinal accessory, in which case the impulses will be conducted from the main channel into two side branches, with conjugate movements of both face and tongue or face and shoulder muscles; or the spinal accessory may be divided and its central end united by end-to-end anastomosis to the distal end of the facial.

*Resection of bone and end-to-end approximation.*—In the event of very extensive destruction of the musculo-spiral or sciatic nerve, it may be necessary to resect such a portion of the humerus or femur as will permit of an end-to-end anastomosis of the divided nerve.

*After treatment.*—Whatever method be employed, the result depends to a large extent on the after treatment—fixation of the limb, massage and electricity. To avoid tension on the part some form of fixed apparatus should be applied, and the limb gradually brought down to the normal position. Massage of the muscles should be commenced not later than the tenth day after the injury.

**Electrical treatment of a divided nerve.***—This consists in the application of electrical currents in such a way that they traverse the paralysed muscles and their nerves, including the injured portion. For muscles showing the reaction of degeneration the continuous current should be used, but the interrupted current may with advantage be used in addition, particularly when the excitability of the muscles to this current is returning. If a sufficiently strong continuous current is not available, the interrupted current may be used, and it will also produce good results. Whichever current is used, it is essential that it should slowly and rhythmically vary in strength. The part to be treated should be immersed in a bath specially constructed, so that the current passes through the water and the immersed part from end to end. If this cannot be done, two electrodes may be applied to the body so as to include between them the part to be treated. The electrodes are made of flexible metal plates, thickly padded with absorbent cloth, and soaked in salt solution. The current, rhythmically varied by a suitable interrupter, is passed from one electrode to the other. When electrodes are used in this way, the current may be obtained from the coil and battery used for testing. If no interrupter is available, some degree of rhythmic variation may be obtained by sliding one of the electrodes slowly along the skin to and fro over the affected muscles and nerves. This movable electrode should be the kathode and it should take the form of a thickly-padded metal disc, not less than

* From information kindly supplied by Dr. E. P. Cumberbatch.

3 inches in diameter, with a handle fixed to its centre. The other electrode may be placed over the site of the injury. The continuous current should be applied first, and it should be as strong as the patient can bear without discomfort. The interrupted current may be applied afterwards, and it should not be strong enough to fatigue the muscles when their power to contract is returning.

At each session the continuous current should also be passed, without rhythmic variation, through the injured part, as it aids in the absorption of any effusion or inflammatory products that may have resulted from the injury. Each session may last from fifteen to thirty minutes, and should be continued every day if possible. This treatment stimulates the muscles and nerves and maintains them in good condition till the nerve has regenerated, and it should be kept up till the maximum voluntary power has returned.

**The incomplete division of a nerve,** whether due to partial cutting through, laceration or bruising, leads to the development of symptoms which, though less definite, closely resemble those observed in cases of complete division. This result is explained by the fact that the conductivity of the nerve is for the time being inhibited, the actual injury to the nerve fibres being associated with a considerable degree of contusion and concussion. Loss of epicritic or light tactile sensation is conspicuous, the area of anæsthesia corresponding more or less to the anatomical distribution of the nerve. Motor power is less disturbed, the degree of paralysis varying according to the number of nerve fibres divided. Loss of function of certain muscles, or of a group of muscles, will be followed by degeneration of those muscular fibres.

Perhaps one of the most important features in the diagnosis between a complete and an incomplete lesion lies in the presence, in the latter case, of pain and tenderness of the skin over the area supplied by the nerve in question. Herpetiform eruptions may be observed in some cases.

In the event of mere contusion of the nerve, a complete functional recovery will take place at an early date. The persistence of symptoms is strongly suggestive of a more complete lesion. The electrical reactions of the muscles will also assist in the differential diagnosis.

*The partial reaction of degeneration.*—It sometimes happens that after injury to its motor nerve the muscle, though contracting sluggishly when stimulated by the continuous current, yet retains some irritability to the interrupted current. It is then said to show the partial reaction of degeneration. It indicates that the injury has not been a complete division. The complete reaction of degeneration may follow severe contusion as well as complete division of the nerve, but progressive loss of irritability is more in favour of complete division.

*Treatment.*—Unless it is clear that the nerve is merely contused, an operation should be carried out for its exposure and repair. The edges of an incised nerve are brought together with one or more silk sutures, but under more serious local conditions the lacerated part should be excised and an end-to-end anastomosis carried out.

## Injuries and Diseases of Special Nerves.

The first (olfactory), second (optic), third (oculo-motor), fourth (trochlear) and sixth (abducens) nerves are dealt with in the chapters dealing with *Fractures of the Skull and Tumours of the Brain.*

**Neuralgia of the fifth nerve.**—The neuralgias arising in connexion with the fifth cranial nerve should be divided into two groups—the neuralgias minor and major.

The **minor** types include such pains in the distribution of the nerve as are dependent on some local exciting cause, such as errors of refraction, dental caries, affections of the mouth and throat, diseases of the antra and accessory sinuses of the nose. As a rule these minor types may be differentiated from the far more serious major type by the following features :—The presence of some detectable source of irritation, the relief of the pain on the successful treatment of that cause, the continuous character of the pain, and the comparative absence of those paroxysmal attacks which are so typical of trigeminal neuralgia or neuralgia major.

In cases bordering on the marginal line careful observation and the effect of treatment will soon clear up the diagnosis. It should be noted that the extraction of sound teeth, for the purpose of diagnosis, is quite uncalled for.

**Treatment of neuralgia minor.**—This consists in the removal of the cause, attention to the general health of the patient, and the relief of pain by means of such drugs as quinine, aspirin, heroin, etc.

**Neuralgia major (trigeminal neuralgia, tic-doloreux).**—This type of neuralgia most commonly originates in the inferior dental and lingual branches of the third division of the nerve, spreading centrally (towards the Gasserian ganglion), then involving the second division also and, more rarely, the first (ophthalmic) branch.

The patients are usually between forty-five and sixty years of age ; men are affected more commonly than women, and the right side of the face more frequently than the left.

The *pathology* is obscure. It is generally regarded in the light of an ascending neuritis, originating peripherally, spreading towards the Gasserian ganglion and there terminating.

**Symptoms.**—The pain is most intense, paroxysmal in nature, and sometimes so severe as to produce complete collapse. The attacks at first last perhaps a few seconds only, originating quite suddenly, but of infrequent occurrence. Gradually the period of freedom diminishes, and the paroxysms become more prolonged and more severe until the patient lives in perpetual dread of their development. Very slight stimuli—such as talking, eating, smiling, etc.—suffice to bring about their onset. The patient's life becomes almost unendurable ; he cannot eat or sleep, nutrition suffers proportionately, and he emaciates rapidly.

The skin and mucous membranes supplied by the nerve become hyperæmic and hypersensitive and the tissues œdematous. Herpes, salivation, sweating, lachrymation, conjunctivitis, keratitis, furred tongue (on the side of the lesion), are other evidences of vaso-motor and trophic change.

*Treatment.*—Many therapeutic remedies have been tried, all with very modified success, and till Schlösser, in 1903, introduced his method of *alcohol injection* into the nerve trunks, a cure could only be brought about by the removal of the Gasserian ganglion. This alcohol treatment is based on the following facts :—Injection of absolute or 80 per cent. alcohol into the nerve trunks produces such immediate destruction of most, if not all, of the nerve fibres that the area previously supplied by the nerve immediately becomes anæsthetic, and the patient is relieved of all pain. It is true that motor fibres suffer as well as the sensory, and that the masticatory muscles are paralysed on the affected side. This, however, is a small price to pay for the complete relief of the intolerable neuralgia. If the injection be successful both anæsthesia and paralysis last for a period varying between six months and a year. The symptoms may then gradually redevelop, presumably due to

recovery of some nerve fibres and regeneration of others. The injection is then repeated, with similar results on skin and muscle as before, and perhaps of an even more durable character. The technique of the injection is as follows:—The needle should be strong, provided with a blunt stilette and graduated in centimetres. The injection fluid may be eucaine 2 grains, absolute alcohol 6 drachms, with water to the ounce. A general anæsthetic is inadvisable, as the accuracy with which the needle can be inserted depends largely on the patient's sensations. The skin may be rendered anæsthetic or the patient may be given a hypodermic injection of morphia half an hour previous to the operation. The needle is introduced, and when in contact with the nerve trunk, as evidenced by acute darting pains in the course of the nerve, the stilette is withdrawn and the syringe fitted. The injection is made slowly, a few drops at a time, up to 1 or 1·5 c.c.

To reach the *foramen ovale* (third division of the nerve) the needle is introduced through the cheek at the lower border of the zygoma, 2½ cms. in front of the descending root of that bone. The point of the needle is directed inwards and slightly upwards. It is then pushed onwards till it reaches the foramen, at a depth of about 4½ cms.

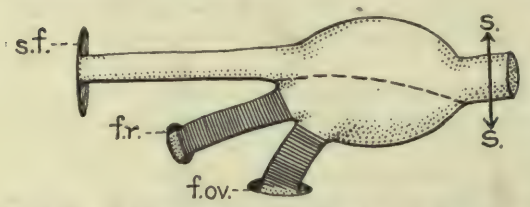



FIG. 111.—To illustrate the operations on the Gasserian ganglion. *s.f.* Sphenoidal fissure. *f.r.* Foramen rotundum. *f.ov.* Foramen ovale. *s.s.* Frazier's operation on the sensory root. The dotted line indicates the line of section in the removal of the lower two-thirds of the ganglion (Jonathan Hutchinson's operation). The cross-lining shows the parts removed in resection of the second and third divisions (Abbé's operation).

To reach the *foramen rotundum* (second division) the needle is introduced below the zygoma, ½ cm. behind a line drawn vertically downwards from the posterior border of the orbital process of the malar bone. The needle is introduced inwards and slightly upwards, the foramen being reached at about 3 cms. from the surface.

In both cases some practice is required to hit off the nerve trunks at their foramina and to avoid important neighbouring structures. For example, in the case of the third division, a needle directed too low may penetrate the pharyngeal wall or injure the Eustachian tube; if too far back, the middle meningeal artery.

There can be no question that endoneural injections of alcohol are more beneficial in their results than perineural applications. A successful attempt is at once followed by sharp burning pain in the course of the nerve, then, in a few minutes' time, by anæsthesia and paralysis of the parts supplied by the nerve.

In cases with extensive distribution of the neuralgia, attempts have been made, with considerable success, to introduce the alcohol *directly into the Gasserian ganglion*. One such method is as follows:—The mouth being propped open, the cheek retracted and the mucous membrane painted over with iodine, the needle is introduced at the upper mucous reflection above the last molar tooth. It is passed directly backwards, parallel to the upper alveolar margin, for about 1½ cms., when it usually comes into contact with the outer surface of the external pterygoid plate. The direction of the needle is then altered, the outer end being thrown downwards in such a way that the needle is now passed upwards and inwards, aiming for a point midway between the pupil and the tragus of the ear, and introduced for a *total depth*

of 4½ to 5 cms. The needle either strikes the base of the skull in close relation to the foramen ovale or, traversing the foramen, reaches the ganglion. Contact with the ganglion is shown by the development of sharp burning sensations along the course and distribution of the fifth nerve, frequently associated with facial spasm on the same side.

On reaching the ganglion it is important that the needle should not be introduced further for fear of injuring the cavernous sinus or internal carotid artery.

Alcohol injections are not invariably successful, and even when correctly applied do not of necessity completely relieve the neuralgia, in which cases operative measures are indicated.

**Operative treatment.**—All peripheral measures on the terminal branches of the fifth nerve—inferior dental, lingual, etc.—are altogether useless for the

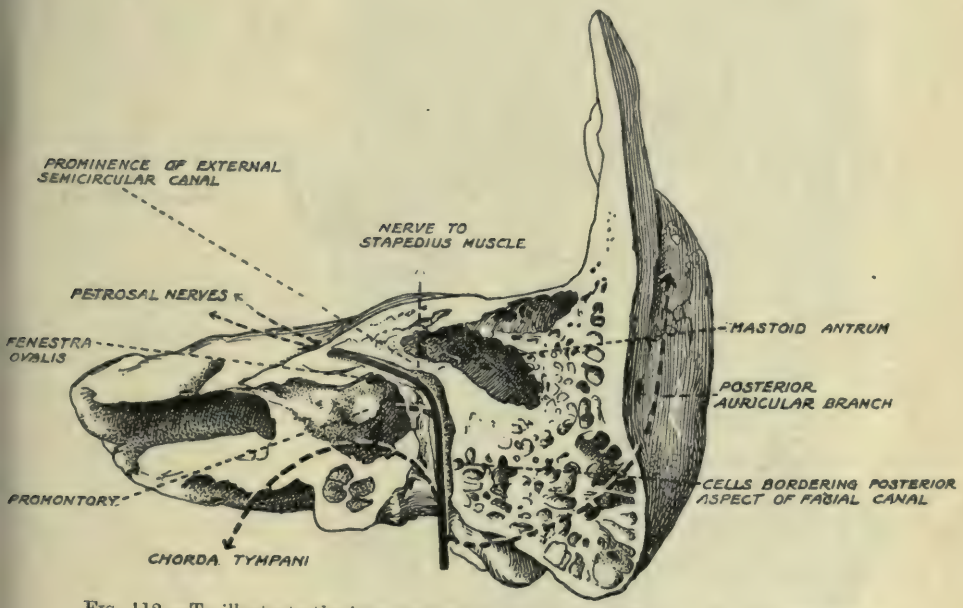



FIG. 112.—To illustrate the intra-petrous course and distribution of the facial nerve.

permanent relief of the neuralgia. Operative measures, to be successful, must be conducted intracranially, on the ganglion itself, its sensory root or three terminal branches. The approach is carried out from the temporal region (Hartley-Krause operation). An incision is made from above and behind the external angular frontal process, along the temporal crest and curving down to the tragus of the ear. A flap is turned down to the zygoma, comprising the whole thickness of the scalp. The skull is trephined and the bone cut away in the forward, backward, and downward directions till a gap is made about 2 inches in the antero-posterior direction by 1½ inches in the vertical. Care must be taken to avoid injury to the middle meningeal artery. The dura, together with the underlying temporo-sphenoidal lobe, is gently retracted, the membrane being stripped away from the base of the skull. The middle meningeal artery, ramifying over the dura, guides the operator towards the foramen ovale, this foramen lying immediately anterior and internal to the foramen spinosum. The dura mater is stripped away

from the third division of the nerve and the foramen rotundum then identified, this lying anterior and internal to the foramen ovale. The dura is stripped away from the second division until the angle of junction between the two divisions is identified. This being done, Abbé contented himself by resecting the intracranial portions of the two nerve trunks, after which, to prevent possible regeneration of nerve fibres, the two foramina should be occluded by cement, wax or wooden or ivory pegs.

In the removal of part or whole of the Gasserian ganglion, the dura is further stripped backwards, thus exposing the ganglion itself. The whole ganglion may be removed or the lower two-thirds only. The complete removal is the more difficult operation, and there is necessarily some subsequent risk of ocular complications—conjunctivitis, keratitis, sloughing

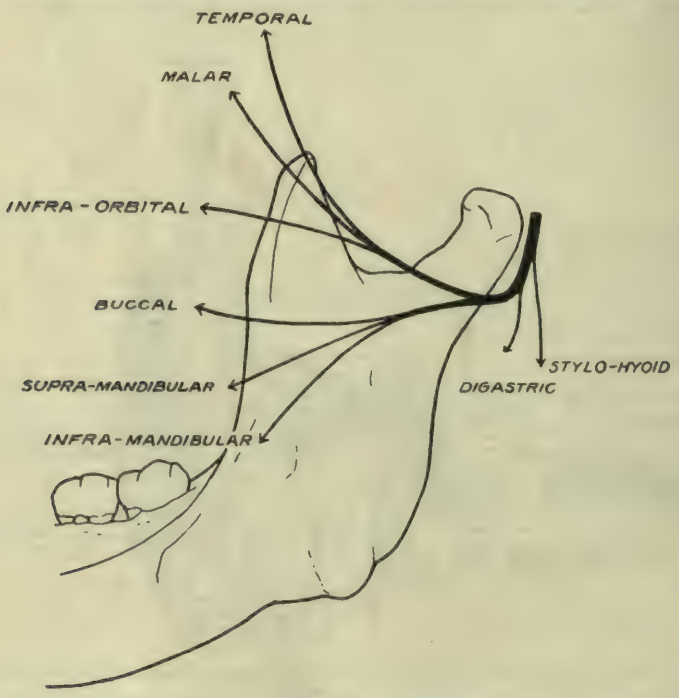



FIG. 113.—The course and distribution of the facial nerve after its emergence from the stylo-mastoid foramen.

of the cornea, etc. It is recommended by Jonathan Hutchinson that the lower two-thirds alone should be removed, in which case, insomuch as the first division of the fifth nerve remains intact, there are no eye troubles. In addition, it is pointed out that the first division is seldom involved in the neuralgic process.

There is still a third measure which presents many advantages over the others—the exposure and division of the sensory root of the ganglion. The middle meningeal artery is divided and the dura stripped away from the back part of the ganglion. When exposed a hook is passed round the sensory root and the nerve divided or avulsed.

In all probability the two most successful operative measures are intracranial resection of the second and third divisions, for subjects the reverse of robust, and resection of the sensory root in other cases.

The operative mortality is small, not more than 5 per cent.; the cure is absolute and permanent—at the small expense of some anæsthesia and paralysis of the masticatory muscles of the affected side.

**The seventh or facial nerve.**—(1) *Paralysis* of the nerve partakes of the *supranuclear*, *nuclear*, or *infranuclear* type, according to whether the lesion is situated above, at, or below the nucleus of the nerve in the floor of the fourth ventricle.

*Supranuclear paralysis* results from pressure exercised on the cortex by hæmorrhage or tumour formation, from subcortical hæmorrhages and neoplasms, and from capsular hæmorrhages. It is of the "*incomplete*" type, the upper face muscles — occipito-frontalis and orbicularis palpebrarum — escaping. The patient, therefore, is still able to frown, close the eye, etc. This peculiarity is said to be due to the fact that the muscles of the two sides are so constantly acting together that each is supplied from both sides of the brain, any unilateral lesion only partly cutting off the impulses to the one side. In these supranuclear lesions also there is no reaction of degeneration, the muscle fibres being still connected with their nucleus of supply.

FIG. 114.—Left facial paralysis (infranuclear)—ordinary expression. Note the drooping of the mouth, the falling in of the ala nasi, and the absence of frontal furrows on the affected side.

In both *nuclear* and *infranuclear* lesions the paralysis is *complete*. They are distinguished from one another by the fact that nuclear lesions are almost necessarily accompanied by paralyses of other neighbouring cranial nerves. It is difficult to imagine any pathological condition which would pick out the nucleus of the seventh nerve alone.

*Infranuclear* paralyses most frequently result from fracture or disease of the petrous portion of the temporal bone. In the latter case the paralysis

is dependent on destruction of the facial nerve in the aqueductus Fallopii, the result of chronic middle-ear disease. Facial paralysis is also frequently observed as *Bell's palsy*, due, in all probability, to a neuritis of the nerve, the result of exposure to draughts, etc., that portion of the nerve being affected which curls round the condyle of the jaw and enters the parotid gland.

In both nuclear and infranuclear palsies all face muscles are paralysed. The face is drawn to the opposite side, and the eye cannot be completely closed, though the associated upward movement of the eyeball can still be carried out. The forehead is smooth and cannot be wrinkled; the ala nasi falls in; the patient cannot whistle; and tears run over the cheek (epiphora) through drooping of the lower lid and imperfect apposition of the puncta lachrymalia. Food collects on the affected side of the mouth through paralysis of the buccinator muscle. The tongue *appears* to be deflected from the middle line, though in reality its position is unaffected.

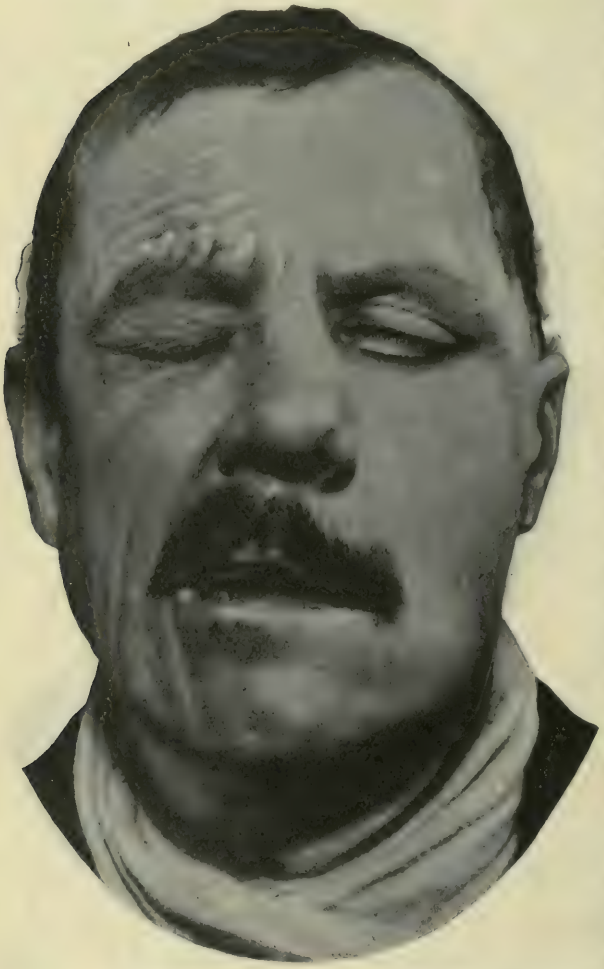


FIG. 115.—Left facial paralysis (infranuclear)—emotional expression. Note the failure in complete closure of the eye, the smooth frontal region, the falling in of the ala nasi, and the drooping of the mouth on the left side.

In addition, when the nerve is destroyed in the petrous bone, either by fracture or disease, there may be some loss of taste (chorda tympani), impaired acoustic sensibility (paralysis of stapedius and tensor tympani muscles), and dryness of the mouth from diminished secretion of the submaxillary gland (? chorda tympani).

Subsequently the facial muscles will degenerate, being cut off from their centre of supply.

*Treatment.*—For the *supranuclear* type reference should be made to the chapters dealing with intracranial hæmorrhages and tumours of the brain. *Bell's palsy* requires no special treatment other than the application of elec-

tricity, associated perhaps with face massage. The *infranuclear* palsies result in such disfigurement that operative measures may be required. The lesion seldom permits of repair of the facial nerve, but some good results have been obtained by anastomosing the distal end of the facial to the hypoglossal or spinal accessory nerve. Either of these nerves may be exposed and divided, the distal end of the facial being joined by end-to-end anastomosis to the proximal end of the other nerve—or the facial may be implanted into the lateral aspect of either of the other two nerves. In any case the hypoglossal may be regarded as the nerve of choice, the associated movements of face and tongue being less conspicuous, and more readily dissociated, than those of the face and shoulder.

2. *Spasm of the facial nerve* (convulsive tic, histrionic spasm).—This condition is characterised by frequent painless twitchings of the facial muscles. It is seen more commonly in women between the ages of forty and sixty. In many cases all the facial muscles are involved, including the platysma, in which case it is probable that the main trunk of the nerve is damaged in some way, more probably in the petrous bone, the nerve being thrown into a state of great irritability and unduly responsive to external stimuli.

In other cases the spasms involve the upper or lower facial muscles, in which case it is likely that the cause is more central in origin.

*Treatment.*—A prolonged course of sedatives, ionisation or galvanism may cure or alleviate the condition. In the event of failure it has been suggested that paralysis of the nerve is preferable to the spasmodic contractures, in which case alcohol injections into the nerve trunk at the stylo-mastoid foramen may be tried (see *Trigeminal Neuralgia*).

FIG. 116.—Wry-neck. (A photograph kindly lent by Mr. G. P. Newbolt.)

**The spinal accessory or eleventh nerve.**—(1) **Spasmodic torticollis.**—This condition is characterised by convulsive periodic or clonic twitchings of the muscles supplied by the spinal accessory nerve, the sterno-mastoid and trapezius. In some cases the nervous impulses are more widespread, the deep muscles of the neck, complexus, splenius, etc., sharing in the change. The twitchings are frequent, forcible and not altogether painless. The attacks, though influenced by emotion, may occur both during the day and the night. The frequency and violence of the twitchings are also subject to considerable variation, the attacks being sometimes so violent that the patient is prevented from sleeping and eating, and nutrition suffers proportionately.

These convulsions, though commonly regarded as of central origin, are closely simulated by muscular twitchings directly dependent on irritation of the spinal accessory in the neck, by enlarged and inflamed glands. It is necessary, therefore, that a careful examination should be made of the neck region.

*Treatment.*—Any exciting cause of nerve irritation should be removed, and in the event of failure to bring about a satisfactory result the spinal

accessory may be exposed in front of the sterno-mastoid and a considerable portion resected. This operation will paralyse the sterno-mastoid and trapezius. When the deep neck muscles are also involved, it may become necessary to expose the posterior divisions of the upper cervical nerves, resecting such an extent of nerve tissue as will prevent any subsequent regeneration of fibres.

The treatment of this condition, surgical or otherwise, is not satisfactory.

2. **Division of the spinal accessory nerve.**—This nerve is not infrequently accidentally divided in operations on the glands of the neck, in either anterior or posterior triangle. If the lesion is in the posterior triangle, the trapezius will be affected; if in the anterior triangle, both sterno-mastoid and trapezius. Both muscles receive some innervation from the upper cervical nerves, and the paralysis is seldom complete.

*Treatment.*—When the accidental division is recognised at the operation, the nerve ends should immediately be anastomosed end to end. If the condition is only appreciated at a later date, massage and electrical treatment should be vigorously carried out, and in the event of failure an attempt may be made to find the two ends by dissection and anastomosis.

**The cervical sympathetic** (see also *Fractures of the Spine*).—The cervical sympathetic may be irritated or paralysed by growths in the neck, more especially those of a malignant and infiltrating type, such as œsophageal carcinoma, secondary malignant disease of the cervical glands, carcinoma of the thyroid, etc. In *paralysis*, the more common condition, the dilator fibres of the pupil—which emerge from the lateral columns of the cord by the first and second dorsal roots and then join the inferior cervical ganglion—are cut off from their area of distribution. In consequence the pupil remains small, incapable of real dilatation. In addition there is some drooping of the upper eyelid, narrowing of the palpebral fissure and some slight recession of the eyeball, with frequent sweats and flushings of the skin of the same side of the face.

*Irritation* of the nerve produces opposite results.

**Recurrent laryngeal nerves.**—The two recurrent laryngeals are situated in the angle between the trachea and the œsophagus, the left hooking round the aortic arch, the right round the subclavian artery. Both nerves are subject to pressure paralysis as the result of aneurysms, mediastinal new growths and new growths in the neck, more especially œsophageal carcinoma. The left nerve, by reason of its longer course, is more often implicated than its fellow. Such pressure paralyses result in *abductor paralysis* of the true vocal cord, the cord of the affected side lying motionless in an almost central position, incapable of being abducted. When both nerves are involved a very narrow respiratory chink remains, the patient suffering from attacks of such urgent dyspnœa as may demand immediate tracheotomy. In addition, it may be mentioned that double abductor paralysis has been observed in some diseases of the central nervous system, more especially in locomotor ataxia.

*Adductor paralysis*, a condition in which both cords remain widely apart and apparently incapable of being adducted, is almost confined to young hysterical females. The false nature of the paralysis may be proved by the application of painful stimuli during the process of laryngeal examination. The cords will then be seen to be capable of approximation.

*Treatment* by galvanism will cure this condition, though the process may be a long one.

It is also stated that true adductor paralysis may result from post-diphtheritic neuritis or other acute laryngeal affection.

**Brachial plexus (injuries of).**—Injuries of the brachial plexus are *complete* or *incomplete*, according to whether the injury involves all or some of the cords of the plexus. The more complete injuries are of rare occurrence, usually resulting from falls or accidents in which the head and shoulder are wrenched in opposite directions, with or without fracture of the clavicle. The *anterior* roots may be torn away from their spinal attachment or the cords seriously lacerated, with hæmorrhage in and around their sheaths. In the former condition the whole upper extremity is in a state of flaccid paralysis with but slight impairment of general sensation. In most cases, however, the patients suffer severely from pains shooting down the arm, in the course of certain nerve trunks. Later on there is considerable muscular wasting and contraction. In the *less complete* injuries, owing to the escape of some of the fibres, there is a mingled state of spasticity and paralysis.

FIG. 117.—A case of birth-palsy (obstetrical palsy—Erb-Duchenne paralysis).

The more common *incomplete* paralyses are typically exemplified by the so-called *birth* or *obstetrical* palsies. Labour is protracted, the presentation is generally vertex, and forceps may have been used. Anyhow, the head has been forcibly deviated from a depressed shoulder, the strain falling on the nerve trunks. The actual nerve lesion varies from a mere stretching of the fibres, with rupture of some and hæmorrhage in and around the sheath, to a more complete injury in which some of the nerve trunks may be torn away from the cord. These palsies are divided into two groups—the *upper* or *Erb-Duchenne*, and the *lower* or *Klumpke*. Erb-Duchenne paralysis is the ordinary type of birth palsy; the Klumpke palsy is very rare.

In the *Erb-Duchenne* type the nerves involved are the fifth and sixth cervicals. The muscles paralysed are the deltoid, supra- and infra-spinatus, teres minor, biceps, brachialis anticus, and supinator longus. In consequence the arm hangs powerless, either limp or rigid, the elbow extended, the forearm pronated, and the whole upper extremity inwardly rotated. There is pain on the application of pressure to the supraclavicular region. Sensory disturbances are unimportant, due to the comparative infrequency of involvement of the posterior or sensory roots.

In most cases a more or less complete recovery may be anticipated, under suitable *treatment*. The arm is fixed in the corrected position, with full relaxation of the paralysed muscles, a splint being applied in such a way that the arm is abducted, externally rotated at the shoulder, flexed and supinated at the elbow. The splint should be removed daily, the whole upper extremity being thoroughly massaged, with passive movements at all joints, this treatment being supplemented later on by electro-therapeutic measures. If there should be no improvement after three months the plexus should be exposed, the conditions investigated, and a suitable anastomosis carried out.

In the *Klumpke* type the nerves involved are the eighth cervical and first dorsal. The muscles paralysed are the flexors of the fingers and the small muscles of the hand, with the later development of a typical claw-hand. This type is " sometimes associated with myosis, narrowing of the palpebral fissure and retraction of the eyeball, phenomena referred to the implication of the oculo-pupillary fibres which pass into the cervical sympathetic from the upper dorsal nerves " (Box and Eccles).

The *treatment* of this type of paralysis follows the general lines indicated for Erb-Duchenne palsy. The forearm is fixed to a splint with the fingers extended, the splint being removed daily for massage, etc.

**Cervical ribs.**—Occasionally a rib may be developed in connexion with the seventh cervical vertebra, attached to the body, articulating with the transverse process, and extending a variable distance in the forward direction. The rib may be short, stunted and beaked at its extremity, or it may pass forward, more or less parallel to the first rib, to be attached to the sternal end of the first rib, either directly or indirectly by means of a strong fibrous band.

The shorter ribs are the more likely to cause pressure on and interfere with the functions of the lower cords of the brachial plexus, eighth cervical and first dorsal, whilst the longer ribs will tend to come into relation with the subclavian artery, which vessel usually hooks over the abnormal rib. In consequence the shorter ribs are the more liable to result in *nervous* phenomena, whilst the longer tend to produce *vascular* symptoms. There is but little doubt that the nervous symptoms are directly dependent on pressure exercised on the nerve trunk by the rudimentary rib. There is, however, some doubt as to whether the vascular phenomena result from a like cause or whether they are due to disturbance of the sympathetic supply to the arterial wall. In any case it should be noted that, when nervous phenomena are prominent, vascular symptoms are more or less non-existent, and *vice versâ*.

The ribs are usually bilateral, though seldom symmetrical. They give rise to well-defined symptoms far more commonly in women than in men. The symptoms seldom commence before the age of twenty to thirty, due possibly to the more complete ossification of the rib and the loss of youthful elasticity.

**Symptoms.**—According as the rib comes into relation with nerves or arteries, the following groups of symptoms are observed—sensory, motor, and vascular.

*Sensory symptoms.*—(*a*) *Subjective.*—The patient complains of tinglings in the hands and fingers (paræsthesia), sometimes on the radial side, at others on the ulnar aspect, also shooting and dull aching pains in the neck, shoulder and down the forearm to the hands and fingers. All such pains are aggravated by work, and at night they may be so severe as to prevent sleep. Most patients will state that they have found some special sleeping posture which

elevates the shoulder girdle and relieves the pressure of the rib on the nerve trunk. (*b*) *Objective.*—There is some slight loss of cutaneous sensation, though this is seldom a marked feature. It is not confined to any special nerve distribution, being perhaps partly median and partly ulnar. There is, however, in most cases a fairly definite patch of anæsthesia along the ulnar side of the forearm.

*Motor symptoms.*—As the result of pressure exercised on the eighth cervical and first dorsal nerves there is degeneration of nerve fibres with consequent

FIG. 118.—A case of bilateral cervical rib. On the left side of the picture the rib is practically complete and presents an adventitious joint. On the right side the rib is smaller.

wasting of muscles, with rigidity and contractures later. There are two main types of paralysis—*median* and *ulnar*. In the former, two muscles of the thenar eminence atrophy, the abductor and opponens pollicis, the flexor brevis often escaping. In the ulnar type there is general wasting of the muscles supplied by the ulnar nerve, with flattening of the hypothenar eminence, wasting of the interossei, and *main en griffe*. More rarely there is weakness of the whole arm or of the higher group of muscles—deltoid, biceps, etc.

*Vascular phenomena.*—The more prominent vascular symptoms are cyanosis and coldness of the distal portions of the affected limb, together with diminution

or absence of the pulse at the wrist, and œdema. Sometimes an obliteration of the pulse is only obtained when the arm is held high above the head. The vascular disturbances have been so marked in some cases that actual gangrene of the fingers has taken place.

The presence and appearance of the rib is readily verified on *radiographic* examination.

*Treatment.*—The symptoms are usually progressive; the pain also is very severe, and the muscular wasting will in all probability result in a more or less useless hand. In consequence, operative measures are indicated in most cases. To be successful the operation must be carried out at an early date—before any considerable muscular wasting has taken place. An incision is made in the posterior triangle of the neck, parallel to the line of the brachial plexus. When identified the cords are *gently* retracted inwards and the position of the rib verified. A large rib is exposed without any great difficulty, but in the presence of a short and stunted rib the operation is more formidable. When exposed the rib is removed whole or in part. As a general rule it is sufficient to exercise that part of the rib which appears to lie in relation to the nerve trunks or subclavian artery.

When carried out early, and with success, the *results* of removal are very satisfactory. The patient is relieved of all pain, further muscular degeneration will be prevented, and considerable recovery may be anticipated in the functions of the hand and fingers. The operation should be followed by a prolonged course of electro-therapeutic treatment.

**The musculo-spiral nerve.**—The long course of the nerve and its anatomical relation to the humerus causes it to be more liable to injury than any other nerve in the body. It is also subject to paralysis in lead-poisoning and other forms of toxæmia. Musculo-spiral palsy is most commonly seen—(1) in association with *fractures of the middle of the shaft of the humerus*, the nerve being lacerated by the ends of the bone, or included in the excessive callus that so frequently forms in this class of fracture; (2) in *crutch palsies*, the nerve being compressed against the head of the bone by ill-fitting crutches, that is to say, by crutches devoid of hand supports; (3) after *hyperextension of the arm* during the administration of a prolonged anæsthetic; and (4) in the so-called "*Saturday night*" *paralysis*, where the patient goes to sleep with the arm hanging over the top of a chair, his alcoholism preventing him from appreciating the resulting discomfort.

The nerve *directly* supplies the triceps, brachialis anticus, anconeus, supinator longus and extensor carpi radialis longior, and innervates *indirectly*, by means of its posterior interosseous branch, all the extensor muscles of the forearm. Its radial branch gives sensation to the radial two-thirds of the back of the hand and the posterior aspect of the thumb, fore, middle and outer half of the ring fingers, as far as the junction between the proximal and middle phalanges.

In lesions *high up, near the shoulder-joint*, the patient is unable to extend the elbow and there is well-marked "*wrist-drop*," the hand falling helplessly forwards and being incapable of extension. The fingers are flexed, owing to the unopposed action of the flexors, though capable of partial extension by means of the interossei and lumbricals. The forearm is pronated through paralysis of both supinators.

When the injury is *below the middle of the humerus*, the triceps, brachialis anticus and anconeus escape, and extension of the forearm is possible.

With respect to *sensory* disturbances, if the nerve be divided or crushed high up, there is considerable diminution of both epicritic and protopathic

sensibilities over the area exclusively supplied by the radial nerve. In crutch palsy and post-anæsthetic and "Saturday night" paralyses the sensory disturbances are much less definite. In such cases also the *prognosis* is good, complete recovery of function being anticipated within a few weeks under appropriate treatment, massage and electro-therapeutic remedies.

*Treatment.*—When the nerve is lacerated in a fracture of the shaft of the humerus it should be exposed at the site of the lesion, the fracture plated, and the nerve ends united end to end. When the nerve is embedded in callus it must be sought for as it emerges from the callus, dug out of its osseous bed, laid in a new channel—*e.g.*, muscle tissue—and protected from fibrous tissue invasion by means of a graft of fascia lata taken from the patient's thigh. In all cases, whatever the operative treatment, prolonged and carefully supervised *after-treatment* is required—massage, electrical treatment, and correction of deformities by means of the application of a suitable splint.

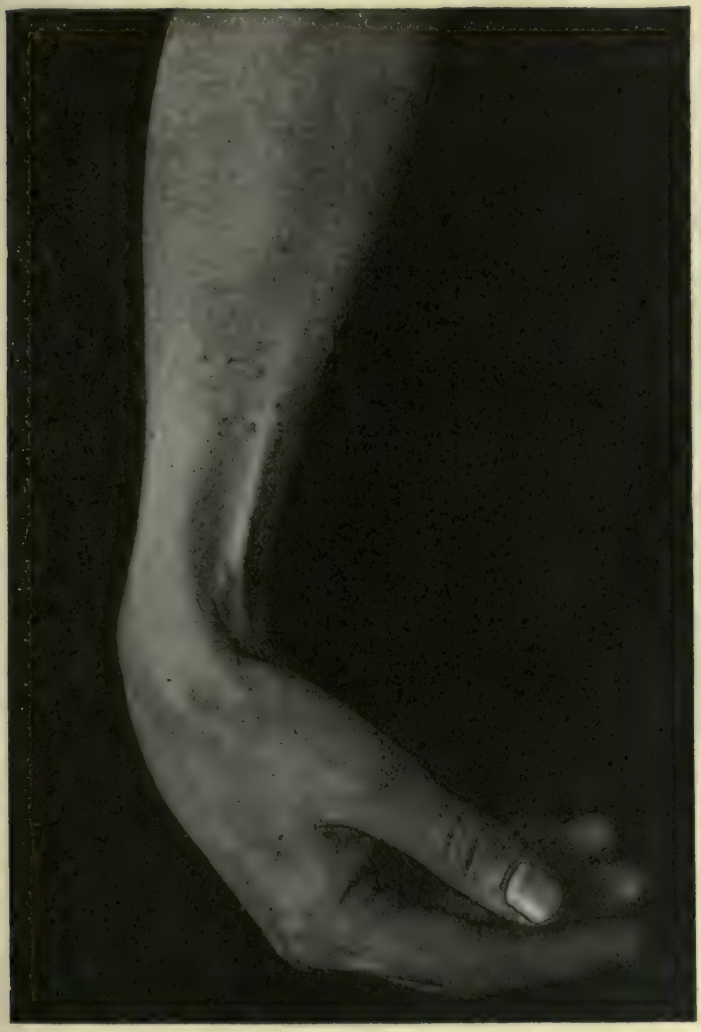


FIG. 119.—"Wrist-drop," after injury to the musculo-spiral nerve.

**The circumflex nerve.**—This nerve, by reason of its encircling the neck of the humerus, is frequently involved in fractures and dislocations in the neighbourhood of the shoulder-joint. The deltoid and teres minor muscles are paralysed in the worst cases, both muscles undergoing rapid atrophy. The shoulder loses its normal rounded appearance, the patient is unable to abduct the arm, all such attempts being accompanied by considerable pain, and there is an anæsthetic area over the lower two-thirds of the skin covering the deltoid muscle.

The *prognosis* should be guarded. Some cases recover completely, in others the muscle remains paralysed, whilst osteo-arthritic changes are liable to develop in the shoulder-joint.

Vigorous *after-treatment* is required—massage of the deltoid and other muscles of the upper extremity, active and passive movements at the shoulder-joint, and treatment by electricity.

FIG. 120.—"Winging" of the scapula after injury to the posterior thoracic nerve (Bell).

**The posterior thoracic nerve of Bell.**—Paralysis of the nerve may result (1) after *prolonged extension of the arm during anæsthesia*, (2) after *breast operations*, and (3) in *extensive injuries of the shoulder region*. In consequence of this paralysis the serratus magnus is paralysed, with "*winging*" of the scapula and impairment of all forward movements at the shoulder-joint, for example in boxing. In addition, owing to the unopposed action of the trapezius, levator anguli scapulæ and rhomboids, the spine of the scapula becomes more horizontal than usual and its inferior angle is approximated towards the middle line.

The *prognosis* as to complete recovery is rather unfavourable. Much patience is required and prolonged *treatment* by massage and electricity.

**The median nerve.**—This nerve is most frequently damaged *immediately above the wrist-joint*, where its exposed position renders it liable to be included in all extensive wounds in that region, whether punctured or incised. Below the level of the wrist the nerve supplies the superficial muscles of the thumb (abductor, flexor brevis, and opponens pollicis) and the two radial lumbricals. It gives sensation to the radial two-thirds of the palm of the hand, the palmar aspect of the thumb, forefinger, middle and ulnar half of the ring fingers, the dorsal aspect of the terminal phalanx of the thumb, and the dorsal aspect of the two terminal phalanges of the other fingers mentioned above.

In consequence of division of the nerve there is loss of power of true abduction and opposition of the thumb and weakness of flexion (the action of the long flexor is unimpaired), with loss of both *epicritic* and *protopathic sensibilities* over an area rather less than that normally supplied by the nerve. The anæsthetic area is not quite so complete as the anatomical distribution of the nerve would imply—there is always some overlapping of neighbouring sensory nerves. *Deep sensibility* is well maintained so long as the flexor tendons are not also divided.

In the course of a few weeks the usual trophic and vaso-motor disturbances will be observed over the area supplied by the nerve.

*Treatment.*—The median nerve is exposed with such ease immediately above the wrist-joint that it should be examined even if doubt exists as to the possibility of injury. The ends are united by end-to-end anastomosis and the hand fixed to a splint in the flexed position, thus relieving tension. The usual *after-treatment* is required.

**The ulnar nerve.**—This nerve is most commonly damaged (1) in *injuries*

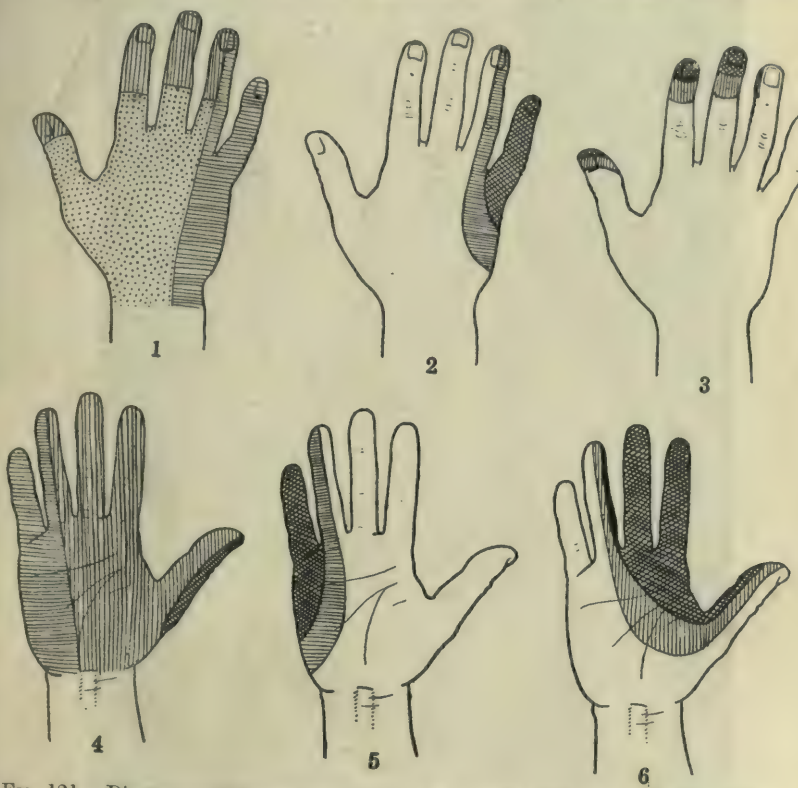



FIG. 121.—Diagrammatic representation of the various areas of anæsthesia resulting from complete division of the median and ulnar nerves. 1 to 3 are of the dorsal aspect of the hand, whilst 4 to 6 are of the palmar surface. 1 and 4 represent the normal distribution of the radial (dotted), median (vertically striped), and ulnar (transversely striped) nerves. 2 and 5 show the areas of epicritic (lightly shaded) and protopathic (deeply shaded) anæsthesia resulting after complete division of the ulnar nerve. 3 and 6 show the areas of epicritic (lightly shaded) and protopathic (deeply shaded) anæsthesia resulting after complete division of the median nerve.

*in the elbow region*, (2) in *operations on the elbow-joint*, and (3) in *incised wounds* immediately above the level of the wrist-joint. The nerve supplies the flexor carpi ulnaris, the ulnar half of the flexor profundus, and the small muscles of the hand with the exception of those few innervated by the median. The sensory supply is distributed to both palmar and dorsal aspects of the ulnar third of the hand and both aspects of the little finger and ulnar half of the ring finger.

When the nerve is completely divided immediately above the level of the wrist the hand assumes the characteristic position of *claw-hand* or ***main en***

*griffe*. The little and ring fingers—and, to a lesser extent, the middle and forefingers—are hyperextended at the metacarpo-phalangeal joint and flexed at the interphalangeal joints. This deformity is due to the paralysis of the interosseous and lumbrical muscles. There is considerable flattening of the hypothenar eminence, due to wasting of the muscles and hollowing out of the interosseous spaces, more especially that between the thumb and

FIG. 122.—*Main en griffe* (claw-hand), after injury to the ulnar nerve.

forefinger. All true abduction and adduction of the fingers is lost, by reason of the paralysis of the interossei.

When the nerve is injured higher up, in the vicinity of the elbow-joint, the wrist cannot be fully adducted, the flexor carpi ulnaris being paralysed. The little and ring fingers can be flexed to a slight degree by means of the flexor sublimis, but flexion of the distal phalanges, carried out by means of the flexor profundus, is impossible. Main en griffe is again a marked feature, and the grip of the hand is greatly impaired.

With regard to *disturbances of sensation*, there is loss of both epicritic and protopathic sensibilities over an area rather less than that normally supplied by

the nerve, this modification again being due to the overlapping of neighbouring nerves, radial and median. *Deep sensibility* is practically unimpaired unless the tendons about the wrist are divided at one and the same time, a common occurrence. Trophic and vaso-motor changes develop within a few weeks.

*Treatment.*—Whenever and wherever divided, the nerve should be exposed and the ends approximated by means of end-to-end anastomosis. The usual *after-treatment* is required—massage, electricity, etc.

FIG. 123.—*Main en griffe* (claw-hand), after injury to the ulnar nerve.

Of the nerves of the *lower extremity*, two only, the *sciatic* and *external popliteal* (peroneal), require mention in this section.

The **sciatic nerve,** by reason of the number of nerves taking part in its formation and their extensive relations to the pelvis and hip-joint, is correspondingly liable to pressure and disease effects. In addition, it is very subject to neuritis, in the majority of cases of toxæmic origin. Sciatica is only a symptom, and careful examination is required in order to investigate

the cause. Tracing the course of the nerve from above downwards, three main regions are to be examined—(1) the spine and spinal cord, for disease and injury; (2) the pelvic organs, for carcinoma of the gut, uterine tumours, sacral growths, etc.; and (3) the hip-joint region, for disease and injury. If the investigation yields negative results, a general examination of the patient is to be carried out in anticipation of the discovery of some source of toxæmia, *e.g.*, pyorrhœa alveolaris.

The *symptoms* observed in cases of sciatica are sufficiently urgent—pain and hyperæsthesia along the course and distribution of the nerve, aggravated on movement, wasting of the muscles supplied by the nerve (hamstrings and leg muscles), foot-drop from paralysis of the extensors of the foot, and the usual trophic and vaso-motor changes. Pain is perhaps the predominant feature—often so severe as to incapacitate the patient from movement and work. For instance, flexion of the thigh when the knee is extended causes exquisite pain, of a shooting and burning character, along the course of the nerve and its branches right down to the foot. In addition, there are points of special tenderness—in the region of the sciatic notch, in the middle of the posterior aspect of the thigh, and deep in the centre of the calf.

In the event of serious injury to the nerve the resultant *anæsthesia* is of the so-called "*stocking*" type, from the toes to within a short distance of the knee. This area, however, is not completely anæsthetic, for the inner side of the leg and foot are supplied by the internal saphenous nerve.

*Treatment.*—This, in general, consists in the elimination of the cause—removal of a spinal or pelvic tumour, vaccine treatment for pyorrhœa, etc. X-rays will be of great assistance in the investigation of the spinal, sacro-iliac and hip-joint regions. Various medicinal remedies, such as aspirin, potassium iodide, etc., may be tried, in association with hydro- and electro-therapeutic measures. Systematic massage will assist in the restoration of muscular function. The process of cure will extend over a considerable period of time.

In the event of failure in bringing about a successful result, it may become necessary to expose the nerve in the thigh, freeing adhesions and incising the sheath of the nerve over a considerable extent.

**The external popliteal or peroneal nerve.**—This nerve is liable to injury in two situations—(1) in division of the biceps tendon, at the upper and outer boundary of the popliteal space, and (2) below the head of the fibula where the nerve curls round the bone to the anterior compartment of the leg. It is in this latter situation that the injury usually occurs, with or without fracture of the bone. In fractures of the head of the fibula the nerve, though not injured at the time, may become included in the callus that forms.

*Symptoms.*—These consist of pain, tingling and numbness referred along the course and distribution of the anterior tibial and musculo-cutaneous nerves, together with painful spasms or paralysis of the extensor muscles of the foot (anterior tibial) and peroneal muscles (musculo-cutaneous). In the event of paralysis there is well-marked "foot-drop." Trophic and vaso-motor changes are more or less confined to the more distal regions supplied by the nerve.

*Treatment.*—The usual treatment of an injured nerve is required—exploration at the site of the lesion and repair or anastomosis, according to the conditions found, followed by vigorous massage and electrical treatment.

## Causalgia.

Causalgia is the term applied to the very severe and persistent pains which occur along the course and distribution of an injured nerve, accompanied by sweating, hyperæmia and hyperæsthesia over the cutaneous area supplied by the nerve. It is a definite neuritis, due to the strangling of the injured nerve by young fibrous tissue, and is associated with local sepsis, and occasionally with the presence of a minute foreign body in the nerve substance.

*Treatment* is unsatisfactory. Alcohol may be injected into the nerve trunk, but probably the best results are obtained by resection of the affected portion of the nerve and end-to-end anastomosis.

## Tumours of Nerves.

The term *neuroma* as applied to tumours of nerves is incorrect, by reason of the fact that but few tumours arising in connexion with nerves consist largely of true nerve elements. The tumours develop from the connective-tissue framework of the nerve, are mainly composed of fibrous tissue, and are more correctly termed *neuro-fibromata*. They are exceedingly divergent in their extent and general characteristics. The following classification will include the more usual types of nerve tumour :—

1. Single neuro-fibroma.
2. Multiple neuro-fibromata.
3. Neuro-fibromatosis.
4. Plexiform neuroma.
5. Ganglionic neuroma.
6. Sarcomatosis of nerves.

A **single neuro-fibroma** occurs as a small tumour on any nerve trunk, cranial, systemic or sympathetic. It arises from the connective-tissue framework of the nerve, more usually from the perineurium, rarely from the endoneurium. In the latter case the nerve fibres are spread out over the surface of the tumour, leading to the formation of an oval swelling, the long axis of which corresponds to the general direction of the nerve. The tumour may be swayed from side to side, but not upwards and downwards in the long axis of the nerve. Pain is a conspicuous feature, more especially on examination. In other respects the symptoms that arise are in direct proportion to the position of the tumour in relation to the nerve and the functional importance of the nerve itself. The following examples of single neuro-fibromata may be cited :—The *acoustic tumours*, neuro-fibromata arising in connexion with the sheath of the auditory nerve in close relation to the internal auditory meatus; neuro-fibromata developing in relation to the *spinal nerves*, more especially the posterior sensory roots; neuro-fibromata developing after the *division of a nerve* or in *amputation stumps* (bulbous ends); and *Wood's tumour*. The first two varieties are treated elsewhere. Wood's tumour occurs as an isolated subcutaneous swelling, oval in shape and having the general characteristics of a neuro-fibroma. It is exceedingly painful and more commonly situated on the lower extremity. In all probability it is connected with the fine terminal filaments of a sensory nerve.

**Bulbous ends (amputation neuromata).**—After the amputation of a limb, more especially when the amputation has been followed by local sepsis, "bulbous ends" may result. This condition is characterised by a node formation at the end of the nerve, which is exquisitely painful on examina-

tion and contact. The bulb consists of fibrous tissue, with a few distorted and immature axis cylinders. It is often adherent to the scar of the amputation, and involves both large and small nerves. Recent investigation shows that the bulbous formation is largely dependent on sepsis.

*Prophylaxis.*—All the larger nerves should be carefully isolated at the time of amputation and divided as high as possible with a sharp, clean knife. The nerve should be crushed with pressure forceps at the proposed site of section, thus dividing the axis cylinders but leaving an intact sheath which is ligatured with catgut in the attempt to prevent infection of the cut end of the nerve.

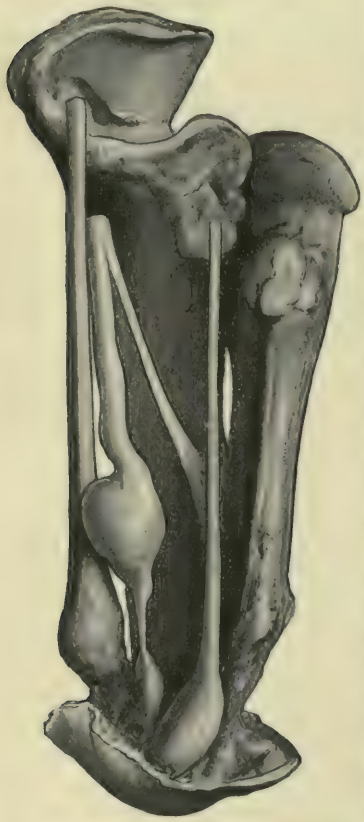


FIG. 124.—Bulbous ends on the median and ulnar nerves after amputation through the middle of the forearm. (St. Bartholomew's Hospital Museum.)

*Treatment.*—Complete excision of the bulb, together with some two inches of the trunk above. The injection of 80 per cent. alcohol into the nerve may be followed by success, but the results obtained are uncertain.

**Multiple neuro-fibromata** resemble the single variety in all respects except in their number and distribution. Innumerable tumours may be scattered over the surface of the body, and in the deeper parts also, but involving in the main the surface of the extremities. The tumours are almost invariably quite small, sometimes so minute as to be scarcely palpable. Many are very tender. They arise from the sensory nerves.

**Neuro-fibromatosis.**—In this condition not only are there innumerable tumours, fibrous and myxomatous in nature, in the course and distribution of the sensory nerves, but, in addition, the tumour formation is accompanied by many changes in the surrounding tissues. For example, neuro-fibromatosis includes all the various grades of *von Recklinghausen's disease—molluscum fibrosum, pachydermatocele, spurious elephantiasis*, etc. The tissue changes, development of fibrous tissue and its myxomatous degeneration, together with lipomatous and nævoid formation, are marked in all forms of neuro-fibromatosis. In molluscum fibrosum hundreds of small tumours may be seen over the surface of the body, some sessile, others pedunculated, subcutaneous in position with a more or less normal skin covering. They are seldom particularly painful, merely unsightly and inconvenient. It would appear that each tumour is related to the skin terminations of various sensory nerves. In some cases the tissue changes are predominant, the skin becoming thickened and thrown into folds (*pachydermatocele*), whilst in others, more especially when the lower extremities are involved, the skin and subcutaneous changes are so excessive that a condition arises *alike to true elephantiasis.*

In **plexiform neuroma** the neuro-fibromatosis is confined to some individual nerve or plexus of nerves, more especially the fifth and twelfth cranial nerves and certain of the larger nerves supplying the upper and lower extremities, the changes following out the nerve to its final distribution, all the branches of the nerve being enlarged and tortuous. The altered nerves feel like a bag of worms, the overlying skin, though stretched and thrown into folds, being otherwise little altered. The changes are mainly concerned with the endoneurium, a diffuse overgrowth with, on transverse section, a gelatinous appearance. With the exception of some pain on manipulation the functions of the nerves may be but little impaired.

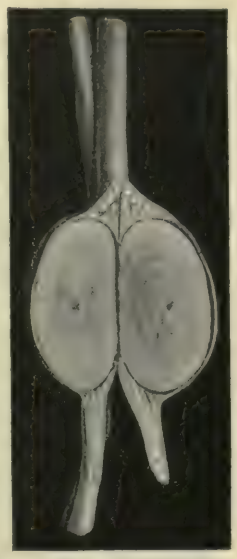


FIG. 125.—Fibroma of nerve. The nerve fibres are spread out over the tumour. (St. Bartholomew's Hospital Museum.)

**Ganglionic neuroma.**—A very rare tumour composed of nerve cells, nerve fibres and neuroglia, occurring in the sympathetic system and subcutaneous nerves, and supposed to originate from the terminal fibres of the sympathetic nerves accompanying the blood-vessels.

**Sarcomatosis of nerves.**—All types of nerve tumour are liable to sarcomatous degeneration, and, in addition, there are a few cases described of primary spindle-celled sarcoma of individual nerves. Though chronic in nature, they follow the usual course of sarcomatosis in general.

*Treatment.*—Isolated neuromata, more especially when painful, require excision, great care being taken in the process of removal to avoid injury to the axis cylinders. The bulbous ends of amputation stumps are dissected away and the nerve trunks dragged down and cut short. Acoustic tumours and tumours of the cord are dealt with in other sections. The various forms of neuro-fibromatosis are seldom amenable to surgical treatment, though in some cases plexiform neuroma has been treated successfully by excision. In the more serious cases amputation of the limb may be necessitated.

# Section VIII.

## SURGERY OF THE SKULL AND BRAIN.

### Congenital Injuries and Deformities of the Skull and Brain.

### Cephaloceles.

The term "*cephalocele*" is applied to all tumours of congenital or traumatic origin which result from the projection of the brain or meninges through a gap in the vault or base of the skull. The origin of a congenital cephalocele is explained in the following manner: — The brain is developed from neural epiblast, the membranes from the surrounding mesoblast, and the skin from surface epiblast. Later on the membranous vault of the skull is developed in the deeper layers of the dermis, thus separating the scalp from the membranes. This rather complicated process may fail in such a way that, either through a defect in the formation of the membranous vault or through fusion of the various layers, a gap is left through which brain or membranes may protrude. It is probable that cephaloceles result in the main from a fusion of the layers rather than from a mere defect in the formation of the skull, for not only do many of them contain a mingled mass derived from neural epiblast and mesoblast—as evidenced by the presence of nerve elements, muscle fibres, fat tissue, etc.—but it is quite common to find that the cephalocele is adherent to the surface integument from the very beginning. In fact it would appear that many cephaloceles are actually *teratomatous* in nature.

Fig. 126.—A case of occipital cephalocele.

*Situation.*—They occur most commonly in the occipital region, either high up as a *supraoccipital* cephalocele, extending into the posterior fontanelle, or low down as an *infraoccipital* type, now tending to involve the foramen

magnum and not infrequently complicated by a condition of cervical spina bifida. Next, in order of occurrence, come the *sincipital or frontal* varieties, *nasal* when situated at the base of the frontal bone between the two nasal bones, *naso-frontal* when between the frontal and nasal bones, and *naso-ethmoidal* when placed between the nasal process of the frontal bone and the ethmoid bone. More rarely they are found in relation to the anterior fontanelle, in the middle line, or projecting through a gap in the base of the skull (basal cephaloceles), either between the base of the sphenoid and occiput or through the cribriform plate of the ethmoid. In these two latter situations there is some danger that they may be mistaken for a pharyngeal tumour on the one hand and for a nasal polypus on the other.

FIG. 127.—A case of fronto-parietal cephalocele. The stalk of the tumour was related to the anterior fontanelle.

Cephaloceles vary very considerably in *size*, being usually quite small when sincipital in position and of considerable dimensions when related to the occipital region.

The membranes alone may protrude (*meningoceles*), in which case the sac will contain cerebro-spinal fluid only, but it is more usual to find in the cavity of the sac either true brain substance or mixed material composed of mesoblastic and neuroblastic tissues (*meningo-encephalocele*).

The tumour varies in *consistency* according to the contents. It may be tense or flaccid, firm or fluctuating. Meningoceles are usually translucent, though it is dangerous to pay too much attention to this point alone, for a meningo-encephalocele may have its contained brain substance at the base of the swelling only, corking up the gap in the bone, the rest of the projection being translucent.

Pulsation is more likely to be present when the tumour contains a considerable quantity of brain matter, the normal pulsation of the brain being readily transmitted to the surface. Some meningoceles, more especially those possessing but a narrow communication with the intracranial space, are not pulsatile.

In all cases the tumour will swell up and become more tense when the

child strains, whilst in some a reduction in size may be brought about by squeezing the tumour. This aid to the diagnosis must be carried out with caution, for the application of pressure is likely to bring about general convulsions. Meningoceles are more likely to be considerably reduced in size than meningo-encephaloceles, whilst, on the other hand, the advent of convulsions suggests strongly that the tumour contains brain substance.

The tumour is generally somewhat narrowed at its base, though a really constricted pedicle—which means a very small opening in the bone—is seldom observed.

The skin overlying the tumour varies considerably. In some cases it appears quite healthy, but as a general rule it is thinned, almost membranous, and sometimes actually ulcerated.

All varieties of cephalocele are likely to be associated with other congenital deformities, more especially hydrocephalus, talipes and cleft palate.

The diagnosis between a meningocele and a meningo-encephalocele is not always readily obtained. The following points require consideration :—

| **Meningocele.** | **Meningo-encephalocele.** |
|---|---|
| Tumour translucent. | Not so. |
| Tumour tense and fluctuating. | Tumour firm. |
| Feebly pulsatile. | Markedly pulsatile. |
| Neck of tumour narrow and small gap in the skull. | Neck of tumour large and considerable gap in the skull. |
| No pressure symptoms present. | Often present (spasticity of limbs, exaggerated knee-jerks, Babinski, etc.). |
| Diminution of tumour after aspiration. | Little or none. |
| Pressure on the tumour causes no pressure symptoms. | May throw the child into general convulsions. |

*Prognosis.*—This is eminently unfavourable. It is true that small meningoceles, more especially when of the sincipital variety, are compatible with life, and that in some few cases surgical treatment has been entirely successful. Still, in the great majority of cases, death supervenes at an early date—from fits, convulsions, etc.

*Treatment.*—It is obvious that the ideal form of treatment is the removal of the tumour. This method, however, must be restricted to certain cases. Large tumours containing brain matter, cephaloceles complicated by marked hydrocephalus or microcephalus, and cephaloceles of all types which are covered by badly-ulcerated skin are beyond the reach of surgery. In such cases all that can be done is to protect the tumour from pressure and endeavour to improve the condition of the integument, with or without aspiration of the fluid contents of the tumour. Aspiration is carried out in a manner similar to that described for the treatment of spina bifida. The needle is introduced through the skin some little distance away from the base of the tumour, then run along the bone and introduced into the sac. The effect of the withdrawal of fluid must be carefully noted, and in any case it is inadvisable to empty the sac completely. The aspiration may be repeated when necessary, and after each aspiration gentle pressure may be applied to the tumour by means of an elastic bandage round the head. By these methods it is possible that a case at first unfavourable for operative interference may be so improved as to come within the bounds of surgical treatment.

Again, the very small sincipital cephaloceles in an otherwise healthy child are best left alone, at any rate for the present. The removal is not carried out without definite risk to the patient, more especially from the point of view of meningeal infection.

Operative treatment, therefore, should be limited to pure occipital meningoceles, to large sincipital cephaloceles, and to those occipital meningo-encephalo-

FIG. 128.—A case of occipital cephalocele. The brain-substance has been removed from the two cavities in order to show their connection. (St. Bartholomew's Hospital Museum.)

celes which are definitely pedunculated. In this last-named variety it is probable that the contained brain matter is of little importance to the individual.

The *technique of the operation* varies according to the case. In principle, two integumental flaps are framed which allow of such tissue remaining as can be approximated at the termination of the operation. These flaps are turned back to the base of the tumour and held aside. The exposed sac is aspirated, sufficient fluid being withdrawn to render the sac flaccid and to prevent the sudden gush of any large quantity of cerebro-spinal fluid. The sac is then slit up, flaps being formed which can be brought together subse-

quently, the remainder being cut away. In the event of the tumour containing brain-like matter, such as is regarded as of no use to the patient, a dissection is carried down to the neck of the tumour and a ligature there applied. The lateral membranous flaps are united with great care, so as to prevent the escape of cerebro-spinal fluid, after which a silver plate may be inserted between the scalp and the bone and overlapping the margins of the gap in the skull. The skin flaps are sewn together and firm bandages applied.

For " Traumatic Cephaloceles," see p. 393.

## Hydrocephalus.

Hydrocephalus, the accumulation of cerebro-spinal fluid in relation to the brain, may be *internal* or *external*, according as to whether the fluid is pent up within the ventricular cavities or between the brain and the dura. The former condition is the commoner. Internal hydrocephalus again may be *congenital* or *acquired*. There are two theories as to the origin of congenital internal hydrocephalus—(1) that there is a hypersecretion of fluid from the choroid plexuses of the lateral ventricle and from its lining ependyma, this fluid escaping at an insufficiently rapid rate ; and (2) that there is a normal output but some impediment to the escape of the fluid from the ventricular cavities. Cerebro-spinal fluid is formed as an active secretion, passing into the third ventricle through the foramen of Monro, thence into the fourth through the aqueduct of Sylvius, and then partly into the central canal of the spinal cord, but mainly through the foramina in the roof of the fourth ventricle (Majendie, Key and Retzius). The fluid now reaches the subarachnoid spaces of the brain and cord. Some of the fluid gravitates downwards along the spine, but the greater quantity passes upwards as a general wave towards the superior longitudinal venous sinus. There it is reabsorbed, for Leonard Hill proved that the intracranial venous pressure is but very slightly below the cerebro-spinal tension.

It is obvious, therefore, that any obstruction to the flow of the fluid from the ventricular cavity to the cerebral subarachnoid space, whether due to congenital abnormality, to the matting of tissues resulting from basic meningitis, from the pressure of a tumour, etc., will dam up the ventricular fluid and produce disastrous results.

The effects on the surrounding tissues will be as follows :—

**Distension of the ventricles, thinning of the cortex and flattening of the convolutions.**—Owing to the accumulation of the cerebro-spinal fluid, the ventricles become greatly distended, all horns, channels, and recesses being proportionately dilated. For instance, the iter may be enlarged up to the size of a lead-pencil or more. The thinning of the cortex is not due so much to actual atrophy of brain substance as to the distension of the ventricles and the corresponding enlargement of the head. The brain matter is spread out over a much larger superficial area than normal. That there is considerable pressure, however, is evidenced by the marked flattening of the convolutions. In quantity the cerebro-spinal fluid may equal 1,000 c.c. or more. The *symptoms* arising from the ventricular distension and cortical changes are both general and local. *General pressure* manifestations are headache, irritability, stupor and coma, associated with incontinence of fæces and urine, vaso-motor changes (*tâche cérébrale*, etc.), vomiting and rapid wasting. The more immediate *local* results, dependent on the irritation and degeneration of the motor cortex and pyramidal fibres, are shown by fits, sometimes unilateral, but commonly generally distributed, rigidity and spasticity of the

lower extremities, with exaggeration of reflexes, and finally by paralysis of the extremities with loss of all reflexes.

**Compression of the cranial nerves.**—The damming up of fluid within the vaginal sheath of the optic nerve leads in the first place to the development of papilloedema or optic neuritis. If unrelieved, this condition soon develops into definite optic atrophy and complete blindness. Other nerves are also involved—the third nerve, with consequent alterations in the size of the pupil, and squints; the seventh, with facial paralysis; the eighth, with

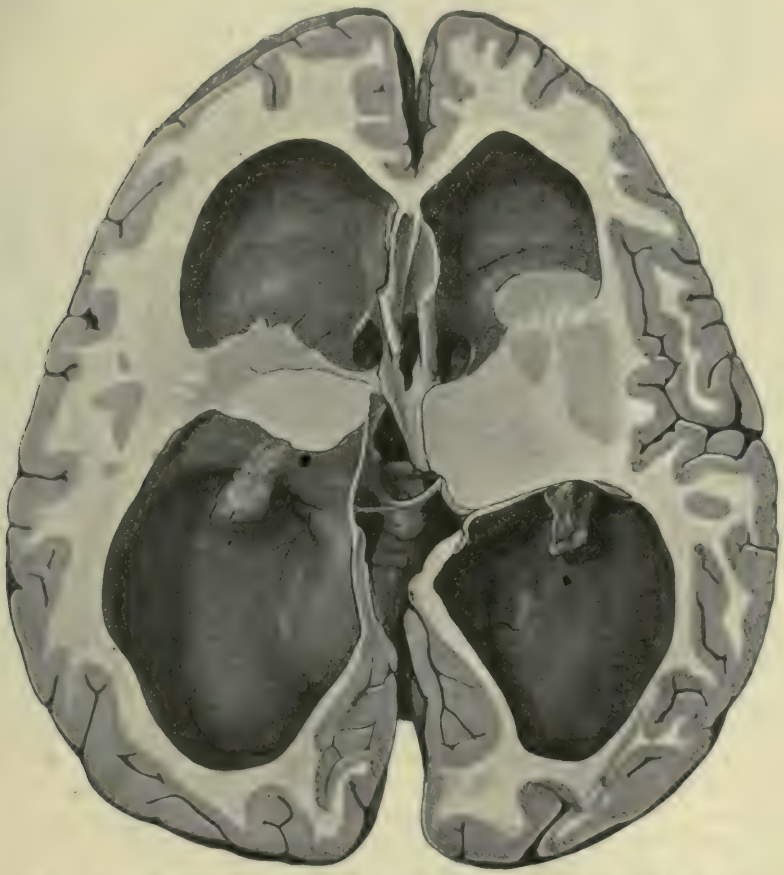


FIG. 129.—Internal hydrocephalus. (St. Bartholomew's Hospital Museum.)

deafness; the ninth and tenth, with dyspnœa and dysphagia; and the upper cervical nerves, with stiffness of the neck muscles and rigidity of the head and neck, and perhaps opisthotonos.

**Enlargement of the head.**—Both vault and base of the skull suffer from the effect of the steadily increasing intracranial pressure. Changes in the vault are seen in the enlargement of the head in all diameters. The frontal bones are bulged out markedly, and there is such flattening of the orbital plates of the frontal bone that the globes are pushed downwards and outwards (*proptosis*); the earlier stages of this condition are shown by the unusual exposure of the supracorneal portion of the white sclerotic. In

addition, the face as a whole appears very diminutive in comparison with the towering forehead and vault.

The head is so overweighted that the child cannot maintain it erect; it falls about and requires to be supported when the child is raised up. The anterior fontanelle, which should be closing at the end of eighteen months and closed at the end of the second year, is unduly open. Under normal conditions the pulsations of the brain are readily transmitted to the soft tissues closing the fontanelle. In hydrocephalus, as a result of the increased intracranial pressure, the fontanelle is tense, even bulging, and pulsations are diminished or absent. The various component bones of the skin are thinned, perhaps membranous, and they may be widely separated from one another, the more important sutures being very apparent.

In most cases of congenital hydrocephalus this enlargement of the head is, as previously stated, steadily progressive. When hydrocephalus is of the acquired kind, similar changes occur if the disease develops before the end of the second year of life, that is to say, before the closing of the sutures and the obliteration of the anterior fontanelle. If of later date, the head cannot show any very appreciable increase in size. In such cases the brain tissue will suffer all the more from the pressure effects, and atrophy of the optic nerve, spasticity from degeneration of pyramidal fibres, etc., all occur very early.

The *scalp* is stretched and thinned, the skin glossy and shiny, and the veins are dilated and prominent. The hair is scant and brittle.

*Progress of the disease.*—Many infants afflicted with hydrocephalus are born dead. In any case, it is unlikely that the child will survive more than a year or two. The development of fits and convulsions suggests the rapid progress of the disease. There are, however, a few cases recorded in which a hydrocephalic has lived to adult age, and there are, in addition, a few individuals who, it is stated, have shown conspicuous genius or ability.

*Treatment.*—The surgical treatment of hydrocephalus is very unsatisfactory. If, however, any benefits are to be derived from operation, the case must be seen and treated before serious degeneration of the brain and cranial nerves has taken place. For instance, if optic atrophy is present, no treatment is of avail. The following methods have been tried, lumbar puncture, ventricular tapping, and ventricular drainage.

*Lumbar puncture* cannot be expected to bring about much benefit, as there is usually little or no communication between the fluid pent up within the ventricles and the spinal subarachnoid space. Every case of hydrocephalus, however, should be tested by means of lumbar puncture, and in the event of the withdrawal of large quantities of fluid at high pressure, the process may be repeated as often as is deemed necessary.

*Ventricular tapping*, the direct withdrawal of fluid from the ventricles, may be carried out over the anterior fontanelle or over the descending cornu of the lateral ventricle. In the former case the needle is introduced at the *outer* angle of the anterior fontanelle, thus avoiding the superior longitudinal venous sinus, passed towards the base of the skull for not more than 2 inches and fluid withdrawn. It is inadvisable to evacuate more than about 50 c.c. at one time. The withdrawal of large quantities will cause collapse of the patient, with perhaps hæmorrhage into the ventricular cavities. In tapping the descending horn of the lateral ventricle a small trephine hole is made immediately above and behind the ear and the needle introduced through the dura mater in a direction towards the summit of the opposite ear. The needle is passed for not more than 2 inches and fluid again withdrawn. The

disc of bone is not replaced. The scalp incision is sewn up. The artificial fontanelle so left allows of subsequent aspiration of the ventricle when necessary.

In both varieties of ventricular tapping a more than temporary benefit is hardly to be expected. Still, either method is of use both in view of the relief of symptoms and with respect to accustoming the patient to the sudden withdrawal of cerebro-spinal fluid, thus preparing the way for more radical measures.

The object desired in *ventricular drainage* is the establishment of an adventitious channel of communication between the ventricular spaces and some other space wherein the cerebro-spinal fluid may be absorbed as quickly as it is poured into it. Attempts have been made to drain from the ventricles into the subcutaneous tissues, into the subdural and extradural spaces, into

FIG. 130.—A case of internal hydrocephalus converted into one of cephalocele by draining into the subcutaneous tissues of the temporo-parietal region.

the spinal canal, and into the superior longitudinal venous sinus. Most of these operations have been followed by very doubtful success. The procedure which appears to be based on the soundest scientific principles and has met with some degree of success is the drainage of the cerebro-spinal fluid into the subdural space.

*Ventriculo-subdural drainage.*—An attempt is made to establish a fistulous communication between the descending horn of the lateral ventricle and the subdural space. Above and behind the ear an osteoplastic flap is framed, the scalp and bone flap being turned down as one, the dura opened and an L-shaped tube, of metal or of bone, introduced in such a way that one arm passes through the thinned cerebral substance into the ventricular cavity, the other being tucked beneath the dura mater, in the subdural space. It is hoped that the cerebro-spinal fluid will drain from the ventricles through the tube into the subdural region, where it may pass upwards towards the superior longitudinal venous sinus, to be reabsorbed.

The dura mater is sewn up and the scalp flap replaced. The operation is not an easy one, nor is it without considerable danger. In the estimation of the risk, however, the generally unfavourable prognosis must be taken into full consideration.

In the place of the L-shaped tube strands of catgut, silkworm gut, etc., have been utilised, one end of the strand projecting into the ventricles, the other insinuated beneath the dura mater. These media, however, are not satisfactory. Metal or bone tubes promise the best results, the tube being allowed to remain in position until the condition of the child improves, when, if necessary, it may be removed.

Many cases die after operation, with general fits, hyperpyrexia, etc.

## Microcephalus.

In microcephalus the diminutive size of the head is due to failure in the development of the brain and is not in any way dependent on the premature union of the skull bones, as was previously thought to be the case. In consequence, all operations carried out with the object of removing such bone from the vault of the skull as will enable the brain to develop are utterly useless. Microcephalics are usually deficient in intellect, and, in addition, they are generally deaf, dumb and blind. Nothing can be done to improve the conditions.

## Birth Injuries.

**Extracranial hæmorrhages.**—As the result of difficult labour hæmorrhage may take place beneath the aponeurosis of the occipito-frontalis muscle and beneath the pericranium. In the former case the blood diffuses widely throughout the subaponeurotic space, leading to a boggy or doughy condition of the scalp, more especially in the more dependent regions—for instance, the occiput. The attachments of the muscle to the occipital crest behind and to the orbital ridges in front prevent any extension of the extravasation into the nuchal and facial regions. Unless complicated by a fracture of the vault, these hæmorrhages require no active treatment. In the course of time the blood is completely absorbed. In the subpericranial variety the hæmorrhage remains localised to one or other skull bone, more commonly the right parietal. Such localised pericranial hæmorrhages are known as *cephalhæmatomata*. Their limitation is due to the fact that the pericranium dips inwards at the margins of the bone to become continuous with the intersutural tissue. In consequence a tumour overlies the bone affected, fluctuating and showing a well-defined and slightly raised edge, the latter peculiarity resulting from the coagulation of the blood in the angle between the pericranium and the bone. This raised edge should be appreciated lest an erroneous diagnosis be made of depressed fracture. As a further aid to the differential diagnosis firm pressure should be made in the centre of the cephalhæmatoma, when the normal condition and position of the bone may be appreciated. Still, it is quite possible that the two conditions, subpericranial hæmorrhage and depressed fracture, are coexistent. When doubt exists as to the exact conditions present, confirmation may be obtained by X-rays. In the event of such aid being not available, exploration will at once clear up all doubt.

In the course of time a subpericranial hæmatoma will be absorbed. This process, however, will require at least one month, and it is better to make a small incision at the most dependent part of the swelling, squeezing out the fluid blood and then applying firm pressure. After this mode of treatment

the patient is well within a few days. Moreover, suppuration may take place in the clot if an expectant attitude be adopted. In the event of operative measures being carried out, such a possibility is scarcely worth consideration.

**Intracranial hæmorrhage.**—Extradural hæmorrhages from the middle meningeal artery are of very rare occurrence. On the other hand, extravasation into the subdural space is by no means uncommon. The hæmorrhage is either cortical or basal. In both cases, however, it results as a general rule from the compression of the head and moulding of the bones of the skull which takes place during a case of difficult delivery. Certain of the superficial cerebral veins may be ruptured. In the cortical hæmorrhages it is probable that certain of the cerebral veins are ruptured in close relation to the superior longitudinal venous sinus. The cerebral veins are embedded throughout the

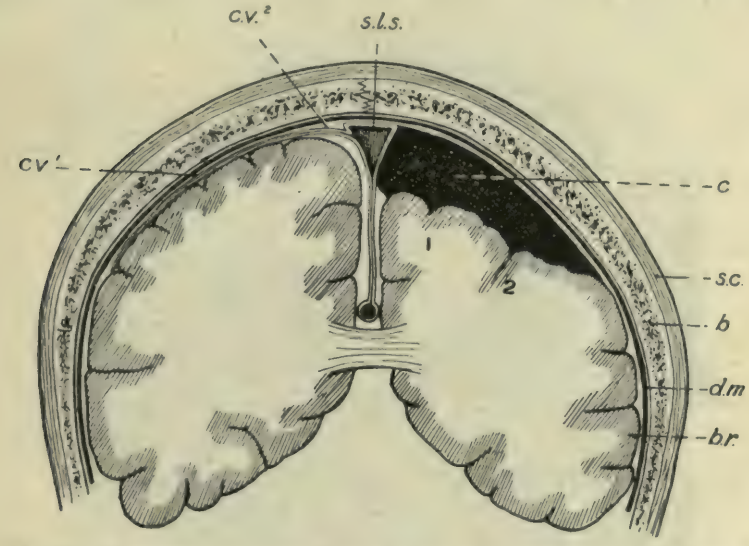



FIG. 131.—Diagrammatic representation of the conditions present in a case of birth (subdural) hæmorrhage. 1. Cortical leg area. 2. Cortical arm area. 3. Cortical face area. *sc.*, the scalp. *b*, the bone. *d.m.*, the dura mater. *br.*, the brain. *c*, the subdural clot. *s.l.s.*, the superior longitudinal sinus. *c.v.*[1], the protected part of a cerebral vein. *c.v.*[2], the unprotected part of a cerebral vein.

greater part of their course in the sulci between the convolutions, but they have to pursue a comparatively unprotected course immediately previous to their entry into the longitudinal sinus. It is in this situation that the rupture usually takes place, and, in consequence, the hæmatoma will be situated in the subdural space, on the surface of the brain and high up, in close relation to the cortical area responsible for the movements of the contralateral lower extremity. The clot may be localised to that region alone, or it may extend downwards over the areas concerned with the opposite upper extremity and face. In addition, the hæmorrhage may be situated on one or on both sides of the falx cerebri.

The *signs and symptoms* of such cortical hæmorrhages are both local and general.

(1) *General pressure manifestations.*—The child is semiconscious or comatose, with full slow pulse and marked cyanosis—the so-called "blue" baby. The

temperature is raised, and respiration is irregular in both depth and rhythm, perhaps even snoring or stertorous.

(2) *Local pressure manifestations.*—Localising symptoms seldom become evident during the early existence of the child—days or weeks elapse before they are observed. They consist mainly in weakness of one or both lower extremities (*mono- or diplegia*) with corresponding exaggeration of reflexes in the affected limb or limbs. Later on, as the result of tract degeneration, the limb becomes spastic, with contractures and deficient growth. If the hæmorrhage extends downwards over the cortical areas responsible for the upper extremity and face, *hemiplegia* is the result. There is every reason to believe that many cases of infantile paralysis are in reality dependent on these cortical birth hæmorrhages.

In some cases the hæmorrhage extends widely over the basal region of the brain. In such cases the symptoms of general cerebral compression are well

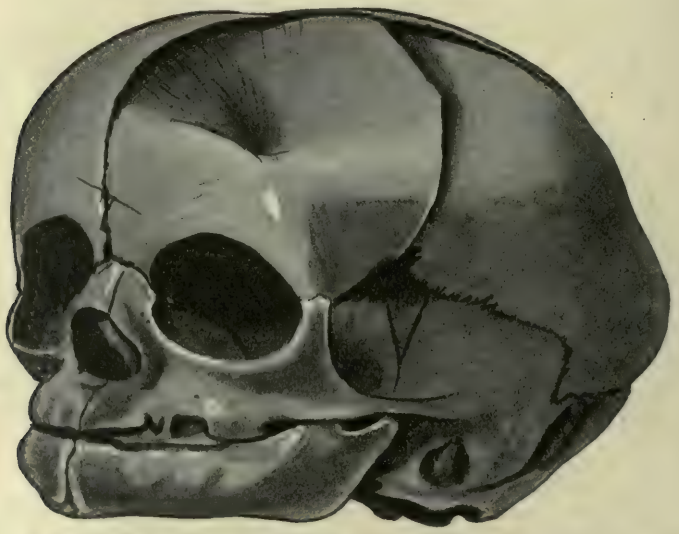


FIG. 132.—The skull in a case of birth fracture. (St. Bartholomew's Hospital Museum.)

developed and the localising features absent, or at any rate obscured by the preponderance of the basal effects.

In both varieties, however, the anterior fontanelle affords a very reliable guide to the general results of compression. It is very tense, bulges in the outward direction, and is non-pulsatile. In addition, the scalp veins may be markedly engorged. The same remark applies to the retinal and orbital veins.

*Lumbar puncture* will, by the presence of blood, intimately mixed with the cerebro-spinal fluid, materially aid in the diagnosis.

*Treatment.*—The child *may* recover from the hæmorrhage, but at the expense of considerable spasticity or paralysis, and as a further argument for operative procedures it should be noted that a new-born baby stands operation well so long as hæmorrhage during the operation is kept under control. After the formation of a suitable scalp flap the bone is trephined over the centre for the lower extremity. The diagnosis being confirmed by the tense and non-pulsatile dura mater and by its plum-coloured appearance, the membrane

is widely incised after cutting away such bone as is deemed requisite for the exposure of the clot. The blood is washed away by gentle irrigation, the dura sewn up and the scalp flap replaced, without drainage.

## Birth Fractures.

Two types of fracture are to be seen, such as occur during the actual birth of the child or shortly afterwards—*depressed* and *fissured* fractures.

**Depressed fractures** usually result from the application of forceps during difficult delivery. The depression is most commonly observed in the fronto-parietal region, varying in extent from a mere dent to a deep concavity. In

FIG. 133.—An extensive depressed birth fracture in the left parietal region.

any case, the actual extent of the depression is likely to be obscured in the early days by an overlying hæmatoma (cephalhæmatoma). In the course of a few days the blood becomes so absorbed as to allow of the recognition of the deformity. The soft skull may be very definitely depressed without any associated fissuring of the bone. Still, in some cases, radiating fissures will be seen, and in all cases the damage to the internal table is greater than that sustained by the external.

The brain is compressed in direct proportion to the depth and extent of the depression.

*Signs and symptoms.*—These vary according to the depth of the depression and its relation to the motor cortex. In any case the symptoms are quite disproportionate to the serious nature of the osseous lesion, the brain of the child adapting itself readily to the altered conditions. Sometimes the child

is quite bright and appears to experience but little ill effect. More commonly, especially when a deep depression is situated over the motor areas, the child suffers from periodical fits, localised in their earlier stages to the opposite side of the body, or from general convulsions with irregularities of respiration, pulse and temperature, all referable to the circulatory disturbances of cerebral compression.

In some cases the child is semiconscious or comatose.

*Treatment.*—This hinges on the question as to whether these depressions are capable of rectifying themselves in the course of time or not. It is quite certain, however, (1) that the more serious lesions are incapable of such natural improvement, and (2) that the brain is liable under all circumstances to suffer permanent damage unless early rectification of the deformity is brought about. From this it is apparent that *operative measures* ought to be carried out without delay in the great majority of cases. As previously stated, the child bears the operation well so long as hæmorrhage is efficiently controlled and the loss of surface heat prevented.

In general it may be stated that the slighter dents and depressions situated over the " silent " areas of the brain—frontal, temporo-sphenoidal lobes, etc. —may be left in the hope that Nature will bring about a cure in the course of time, but that all the more extensive depressions, more especially when related to the motor cortex, should be elevated by operation without delay.

*Operation.*—After the adoption of suitable hæmostatic precautions, a scalp flap is framed, the skull trephined immediately to one side of the depression, the dura mater stripped away from the under surface of the depressed bone, and the depression elevated. In some cases the depression is easily rectified, in others it may be corrected but immediately returns to its previous depressed position, and in a third group the depression cannot be forced out. In the latter two conditions the whole of the depressed bone may be cut out with scissors and then replaced in the reverse position, dural side external. The scalp flap is sutured and firm bandaging applied. The inverted bone unites firmly within ten days or so, without deformity, with normal subsequent growth, and with complete relief to all compression symptoms.

**Fissured fractures.**—This type of fracture, though seldom observed, results as a rule from falls or blows applied directly to the vault during the first few months of life. The fissures in direction tend to follow the lines of ossification of the bone involved. Thus, the fissures radiate from the frontal and parietal eminences. In the most severe cases, however, the fractures pass across the vault or down to the base in the line of the applied force, regardless of all anatomical considerations.

In all cases the fracture of the vault tends to become obscured by the prevailing subaponeurotic or subpericranial hæmatoma, and beyond some primary symptoms of concussion the child is little the worse unless the brain should have been damaged at the same time. In such an event the concussion symptoms are unduly prolonged or evidence of cerebral compression is apparent.

These fissured fractures in the infant present one very marked difference to those of a similar nature occurring in the adult—the fissure tends to increase in width, the rapid development and growth of the brain, associated perhaps with some degree of increased intracranial pressure, preventing union of the fracture and even markedly everting the edges of the bone. This development is most likely to occur if the dura mater has been torn beneath the fracture and if the brain has been damaged locally. Under such circumstances the local and general increase of intracranial pressure may force some brain through the

rent in the dura and out between the margins of the gap in the bone, producing what is called a "*traumatic cephalocele*." Such a condition is seldom recognised till some days after the accident, when the absorption of a scalp hæmatoma allows of the recognition of a wide fissure in the gap. Between the edges of the gap a mass protrudes which pulsates, which is soft, slightly reducible, and which may be in part translucent. The more marked the translucency the less the amount of brain substance in the tumour and the greater the quantity of cerebro-spinal fluid. When cerebro-spinal fluid forms the major part of the swelling the term "*traumatic meningocele*" may be applied. In most cases, however, brain matter occupies the base of the swelling (*traumatic meningo-encephalocele*).

*Treatment.*—The minor types of fracture require no special treatment. If, however, the fissure tends to increase in size, the question should be raised as to whether it is not advisable to expose the fracture, and to wire or lace together the margins of the bone.

The treatment of traumatic cephaloceles is very difficult. In the less severe cases an attempt may be made to rectify the deformity by exposing the fracture, removing any broken-down brain substance, sewing up the dura, and lacing the margins of the bone together. In the more severe cases an expectant attitude may be adopted, efforts being made to control the development of the protrusion by aspiration and the local application of pressure. The prognosis is unfavourable.

## Injuries and Diseases of the Scalp and Skull.

### Wounds of the Scalp.

The larger arteries of the scalp lie embedded and bound up in the dense fibrous tissue intervening between the integument and the aponeurosis of the occipito-frontalis muscle. Beneath this aponeurosis there is a layer of very loose connective tissue containing in its meshwork numerous small vessels. Beneath this comes the pericranium, richly supplied with arteries all communicating with the vessels of the diploë, which, in their turn, anastomose freely with the meningeal arteries. In consequence of this arrangement of tissues and vessels hæmorrhage in the various regions presents certain points of peculiarity and certain special dangers. Thus, an incised wound leading down to but not penetrating the aponeurosis will bleed freely, more especially when the lips of the wound remain widely open, the vessels being unable to contract and retract as is the case in other parts of the body. If, however, the aponeurosis be torn at the same time, the blood will be enabled to extravasate widely throughout the loose connective meshwork of the subaponeurotic space, extending in all directions, but gravitating in the main to the more dependent regions, such as the occipital. The scalp becomes "doughy," and ecchymosis appears within a few hours. The region into which this extravasation takes place is limited in front by the superciliary ridges, laterally by the temporal crests, and behind by the curved line of the occipital bone. These subaponeurotic hæmorrhages are unlikely to be very extensive unless associated with a fracture of the vault, the hæmorrhage then being increased by bleeding from pericranial or meningeal vessels.

In children, and less frequently in adults, as the result of a contusion of the scalp, it is not uncommon to find that a hæmorrhage is confined beneath the pericranium, such hæmatomata being limited in their extent to the particular bone of the vault with which they are connected. The hæmatoma is more or

less circular in outline, fluctuating in the centre, of doughy consistency, but presenting a firm and slightly raised edge around the periphery. This marginal peculiarity is due to the coagulation of the blood at the angle of junction between the pericranium and the bone. Warning is usually given lest a pericranial hæmatoma, by reason of its raised margin, should lead to an erroneous diagnosis of depressed fracture. It should be noted, however, that the two conditions are not infrequently associated, and considerable care is required for the establishment of a correct diagnosis. In fact, any hæmatoma of the scalp may conceal a fracture, and occasionally it is impossible to verify the existence of the fracture till after the partial absorption of the overlying hæmatoma.

The *shape* and *position* of the hæmatoma often supplies information as to the nature of the osseous or intracranial complication. Thus, a hæmatoma of a more or less linear arrangement usually implies a linear fracture of the vault. Again, an extensive hæmatoma confined to the temporal region is almost always associated with a fracture of the temporal fossa and rupture of the branches of the underlying middle meningeal artery. The extradural extravasation in such a lesion escapes through the fissures of the bone and enters the temporal region. Here it is confined by the attachment of the temporal fasciæ and muscle, a tense swelling resulting, showing early ecchymosis of the integument. This swelling may pulsate, more especially on the application of firm pressure. *Pulsating temporal hæmatomata* are regarded as affording conclusive proof of comminution of the bones of the temporal fossa with an extradural hæmorrhage from the middle meningeal artery.

*Wounds of the scalp*, being produced in all sorts of ways, may be of any shape. Often they are ragged and the margins lacerated. The whole wound may be ingrained with dirt, bleeding freely and frequently appearing at first sight much worse than it really is.

The *examination and treatment* of a scalp wound should be conducted with two main purposes in view—the cleansing of the wound in the hope of avoiding suppuration, and its investigation as to the possible existence of a fracture.

In all probability an anæsthetic will be required. The hair is clipped, and a wide area around the wound is shaved. The area of skin exposed is then painted with a $2\frac{1}{2}$ per cent. solution of iodine in spirit, after which the head is covered with a sheet of gauze or sterilised towel in which a hole is cut large enough to allow of adequate space for the examination and suture of the wound. Rubber gloves should then be put on, the whole wound painted with iodine, and the investigation carried out. Care must be taken to avoid mistaking one of the normal sutures of the skull for a fissured fracture.

The scalp has a wonderful blood supply, and parts should never be cut away for fear that they may die. Even in partial avulsion of the scalp the flap should be drawn into position and there sutured, with suitable drainage.

In the average wound of the scalp it is probable that hæmorrhage will have ceased when the case is examined. If bleeding is still taking place it is mere waste of time putting on forceps. They are difficult to apply, and ligatures are always inclined to slip off. If the bleeding is fairly profuse it is far easier to fasten a rubber tube round the head somewhat after the style of the scalp-tourniquet. This can be removed as soon as the wound is sewn up. In sewing up the wound a few catgut stitches may be used to bring together the margins of the cut aponeurosis, after which the edges of the skin are approximated by salmon-gut stitches, each of which picks up plenty of tissue on either side of the wound. These stitches should include not only the skin, but also the vessel-bearing subcutaneous tissue. If correctly inserted, these

stitches, supplemented later by firm bandaging, should be more than sufficient to stop all bleeding.

It is only in exceptional cases that the wound can be closed throughout. In most cases it is advisable to *drain* the wound at the most dependent point for a day or two.

Dressings are then applied, maintained in position by a circular gauze bandage and, if possible, an adjustable head bandage.

In all scalp wounds the possibility of *complete excision of the wound* should be considered, with the object of bringing about union without suppuration. The wound is enclosed by an elliptical incision, the knife being carried down to the bone and the central tissues picked up with the forceps and cleanly removed in one piece. The instruments used are now discarded, gloves changed, and fresh towels applied. The wound is then dried and cleaned, after which, either by free undermining of the scalp on either side or by plastic flaps, the edges are brought together and sutured, a small glove drain being inserted.

In all extensive scalp injuries the patient should be kept in bed till all fear of suppuration and possible complications is over. The toxæmia resulting from scalp suppuration is very definite, and, even if the wound itself appears in fair condition, restlessness on the part of the patient, headache, rise of temperature, and increasing rapidity of the pulse all point to suppuration. In the event of the development of such symptoms, the wound must be opened up and drainage established. The danger of infection of the bone, of the meninges, and of the brain must always be borne in mind. Fortunately such disasters are uncommon. They can nearly always be prevented by free drainage.

The symptoms observed in meningeal and brain infection are treated in a later part of this section.

In the various hæmorrhages unassociated with an external wound—subaponeurotic, subpericranial, etc.—no special *treatment* is required unless the case is complicated by injury to bone or brain. Such lesions are treated elsewhere. The only possible exception to this rule is with reference to subpericranial hæmatomata. In some cases one is enabled to obtain a more rapid cure by aspiration of the fluid blood or by means of a small incision through which the blood is squeezed out. After either method firm bandaging is required to prevent reaccumulation.

## Diseases and Tumours of the Scalp.

**Sebaceous cysts.**—There is no part of the body more liable to the development of sebaceous cysts than the hairy portions of the scalp. That region is richly supplied with sebaceous glands, and the orifices of their ducts are readily blocked. Retention cysts then arise, usually multiple and varying in size from a pea to a pigeon's egg. The tumours are more or less devoid of hair, the surrounding hairs being pushed aside by the bulging of the tumour, and atrophy occurring in the neighbouring hair follicles as the result of the pressure. The tumour is attached to the skin at one spot, the central black spot so diagnostic of a sebaceous cyst. This marks the site of the occluded duct. It is movable on the underlying tissues. Some cysts are painful, due to the inclusion and stretching of a cutaneous nerve. In general, however, they are of slow growth and give rise to little or no inconvenience. The disfigurement is the main complaint. Sometimes they interfere with the setting of a hat. In other cases the tumours are the seat of recurring attacks of inflammation, one of which is sure to end in actual suppuration. Such a

change is marked by the usual signs of inflammation, heat, tenderness and redness, together with œdema of the surrounding tissues.

*Treatment.*—When causing inconvenience the hair is cut and shaved in the immediate neighbourhood and, after the injection of a local anæsthetic, the cyst is dissected out entire and the incision sewn up. A suppurating cyst is incised and the walls dissected away as freely as possible. A small drain should be used for a day or two.

**Sebaceous adenomata.**—In certain cases, more especially in the temporal region, adenomata develop in relation to sebaceous glands. The resulting tumour closely resembles in its earlier stages a sebaceous cyst, but is firm to the touch. In addition it shows a special predisposition to ulcerate, in which event epitheliomatous degeneration is liable to take place. Consequently early excision should be carried out. When definitely epitheliomatous a wider removal is required, together with the excision of any enlarged glands in the parotid, post-auricular, and cervical regions. Such tumours are of low malignancy, and seldom recur after free and early removal.

FIG. 134. — A sebaceous adenoma of the scalp undergoing epitheliomatous degeneration.

**Warts** are of common occurrence and are usually multiple. In all probability they are of infective origin, due to inoculation from the finger nail, etc. When multiple and quite small a vigorous use of mercurial ointment will bring about a cure. Electrolysis of individual warts is also effective. When large and single they should be excised under local anæsthesia.

**Angiomata of the scalp.** — Vascular tumours of the scalp include the various grades of nævi (capillary, venous and arterial), cirsoid and arterio-venous aneurysms.

*Nævi* are of common occurrence, situated on any part of the scalp and usually venous or arterial in nature. The " port-wine " mark so frequently seen on the face rarely involves the scalp proper. Both venous and arterial nævi are usually quite small, varying in colour according to the constituent vessels, fading on pressure, and surrounded frequently by a few dilated capillaries. Unless situated near the eye or over the anterior fontanelle, the smaller nævi may be cured by the time-honoured method of destruction by fuming nitric acid. A few applications will soon cure the nævus, by ulceration. In the more dangerous areas it is best to utilise the more modern methods of ionisation, electrolysis, carbon-dioxide " snow," etc. The same treatment should be adopted in the more marked conditions unless excision appears more likely to bring about an earlier cure. In some of the most serious and deforming cases diathermy may be utilised.

*Cirsoid aneurysm* (aneurysm by anastomosis) is seldom seen except in the temporal region. A dense mass of tortuous and dilated vessels exists, mainly arterial in nature, with no clear margin and with numerous dilated feeding

vessels, running in on all sides. A well-marked thrill can be felt by the examining finger, and a definite hum or bruit can be heard on auscultation. This noise, when appreciated also by the patient, is very distressing. The whole tumour increases in size when the patient lowers his head or strains, and some diminution in size may be brought about by the application of pressure to the common carotid. Cirsoid aneurysms are congenital in origin, but their pathological nature is otherwise obscure.

Attempts have been made at their *removal*, but the operation is a formidable one, and hæmorrhage may be severe. There are no defined boundaries to the tumour, and the feeding vessels are large and thin-walled. Many operations may be required before a cure is accomplished. It may be necessary to expose

FIG. 135.—Lipoma of the frontal region.

all the nutrient vessels of the tumour, ligaturing them one after another, and finally extirpating the main mass. Sometimes the tumour receives considerable tributaries from the underlying bone, in which case the various foramina may be occluded by wax, plugs of bone, ivory, etc. In some few cases it has been found necessary to ligature the common or external carotid artery. Operative interference is usually necessary, as the tumours tend to increase in size, neighbouring vessels being involved one after the other. Some of the more intractable cases have been cured by diathermy.

*Arterio-venous aneurysms* occasionally develop in connexion with the superficial temporal and occipital arteries and veins, usually as the result of punctured wounds in those situations, both artery and vein being injured. The aneurysmal symptoms develop some weeks or months after the accident. The resultant tumour presents many of the symptoms of a cirsoid aneurysm and should be treated in a similar manner—by excision.

**Lipomata** are rare tumours. They are seldom seen except over the frontal bone. They partake of the clinical characteristics of lipomata in general, being soft, circumscribed and often lobulated tumours, connected perhaps with the deeper layers of the skin, with consequent wrinkling, and sometimes attached to the periosteum of the bone. When resulting in any disfigurement they should be removed.

**Fibromata, neuromata** and **lymphangiomata** seldom occur as pure tumours. The varieties are as follows :—(1) **Molluscum fibrosum,** a more or less pedunculated tumour, composed of fibrous, myxomatous and nævoid tissue, arising usually from the lateral aspect of the head. It is moderately firm in consistency, of slow growth, and seldom attains any very considerable size. (2) **Cystic hygroma,** a lymphangiomatous tumour, consisting in the main of a fibrous meshwork, the spaces of which are filled with a serous fluid. The tumour is but feebly demarcated from the surrounding tissues. It may be seen in any part of the scalp, forming an ill-defined soft swelling, translucent, and reducible in part on the application of pressure. It should be removed, though the process of dissection is likely to be tedious. (3) Tumours also are seen which are derived in the main from the sheaths of the nerves of the scalp. These tumours are described as **neuro-fibromatosis** or **elephantiasis nervorum.** They are often associated with similar changes in other parts of the body, more especially in the lower extremity. They may appear as a pendulous mass, overhanging the side of the head, resembling molluscum fibrosum in consistency, but larger and less defined. In some cases the overgrowth has been so excessive that the tumour has been likened to a " Tam o' Shanter " hat. So far as is known, these tumours develop from the thickened and proliferated perineurium of the auriculo-temporal nerve or other sensory nerve of the scalp. There is a regular meshwork of tortuous nerve elements, with admixture of fibrous and myxomatous tissues, all bathed in an excess of serum. If necessary, the tumour may be removed, sometimes a rather formidable operation.

**Pneumatocele and surgical emphysema.**—Pneumatocele of the head is an air-containing swelling usually occurring over the frontal and mastoid regions. The tumour is seldom of any size, but well defined, and yielding on palpation the peculiar crepitation of an air-containing swelling. It may be somewhat reduced on pressure, and increases considerably in size when the patient coughs or sneezes. The *frontal pneumatoceles* are situated in superficial relation to the frontal air sinus, with which they are connected. A fracture of the skull which involves the outer wall of the frontal sinus, or a channel leading from the sinus to the surface, the result of long-standing frontal sinusitis, allows of the escape of air, more especially after straining. If the pericranium be intact, or the tissues sufficiently resistant, the air remains localised. To such collections of air the term " pneumatocele " has been applied. Similar lesions—fracture or disease—lead to the formation of a *mastoid pneumatocele.*

If the air be diffused throughout the cellular tissues *surgical emphysema* results. In this condition the air may spread widely throughout the tissues of the head and neck, even down to the chest, producing considerable disfigurement and extreme discomfort, even danger to life from dyspnœa.

*Treatment.*—When the pneumatocele, whether frontal or mastoid, is dependent on *fracture of the bone,* no special treatment is required, though the patient must be warned against coughing or sneezing. The air will be absorbed. On the other hand, if the process of absorption is slow or the swelling disfiguring, a small incision down to the bone through the pericranium will immediately effect a cure.

When the pneumatocele is dependent on *disease of the frontal or mastoid sinuses,* the usual operations for the cure of such conditions will at the same time effect a cure of the pneumatocele.

In *surgical emphysema* the air in the cellular tissues will continue to spread unless an incision be made down to the bone, in immediate relation to the line

of fracture or the seat of the fistulous channel. The air already contained in the tissues is soon absorbed.

**Rodent** and **epitheliomatous ulcers** are occasionally observed, the former usually involving the scalp in their upward spread from the face, the latter arising from a wart, sebaceous adenoma, scar tissue, etc. They require the same treatment as when situated elsewhere.

**Dermoids** may be seen in relation to the anterior and posterior fontanelles, and they are of frequent occurrence at the inner or outer canthus of the eye, especially in the last-named situation. The tumour when first observed is usually quite small, unattached to the skin, moderately tense, non-translucent and very slightly mobile on the underlying tissues. The larger dermoids may, however, make for themselves a depression in the bone, in which they rest.

Over the vault these dermoids may attain considerable size, and both from their situation and dimensions may simulate a cephalocele, from which they are only diagnosed with difficulty, more especially when the dermoid is connected with the membranes and brain through a considerable cleft in the bone.

The smaller dermoids, such as have no intracranial connexions, may be removed. The others are better left alone.

## Diseases of the Skull Bones.

**Thickening of the skull bones.**—In the normal individual the bones of the skull vary greatly in thickness, but pathological thickening is observed in syphilis of the skull, in acromegaly and gigantism, in osteitis deformans, and other more obscure conditions. In each and all of these cases the thickening is the result of a chronic inflammatory process, the two tables of the skull showing the greatest change, though the diploë also shares in the process.

The bone is generally softer than normal, more porous, and the Haversian canals unduly large and prominent on section. The growth of bone is mainly eccentric, with no appreciable reduction of cranial capacity. In some cases, however, more especially in gigantism, eccentric and concentric processes are concomitant and symptoms of cerebral compression may become evident.

In acromegaly the facial bones are in the main affected, but the skull bones may share in the process, thickening occurring in any or all of the component parts. In osteitis deformans and gigantism the skull may be greatly enlarged in all diameters (for further details of acromegaly and gigantism, see *Tumours of the Pituitary Body* and also pp. 178 and 179).

**Thinning of the skull bones** is seen in syphilis, rickets, hydrocephalus, in the various grades of osteogenesis imperfecta, and rarely as a senile manifestation. In hydrocephalus the progressive dilatation of the ventricular cavities not only inhibits the normal development of the skull, but also results in the absorption of bone already formed. In consequence the bones of the vault may be no thicker than paper—membranous rather than osseous. In both rickets and congenital syphilis a condition known as *craniotabes* is seen. Here, mainly as the result of pressure exercised on a chronically inflamed bone, patches are observed where absorption has taken place. That pressure is an important factor in the production of these thin areas of bone is suggested by the fact that they occur with the greatest frequency in the parietal region, a part which receives the main weight of the child's head when being suckled and nursed.

**Syphilis of the skull.**—The effects of syphilis on the skull are now less

commonly observed than formerly. There are in most museums specimens illustrating the two main effects of congenital syphilis—*craniotabes* and *Parrot's nodes*.

In a typical case of Parrot's nodes it will be seen that there are four regions of thickening, over the frontal and parietal bones, forming the so-called *hot-cross bun* or *natiform* skull. Allusion has already been made to craniotabes.

Formerly, the tertiary or gummatous stage of acquired syphilis was of frequent occurrence. At the present day gummata of the skull are but seldom seen. The disease starts as a subperiosteal gummatous infiltration, usually in the fronto-parietal region, with the formation of one or more soft, rounded, fluctuating tumours, attached to the bone and with fairly well-defined margins. Under appropriate treatment these gummata usually subside, leaving, however, some degree of new bone formation. Nevertheless,

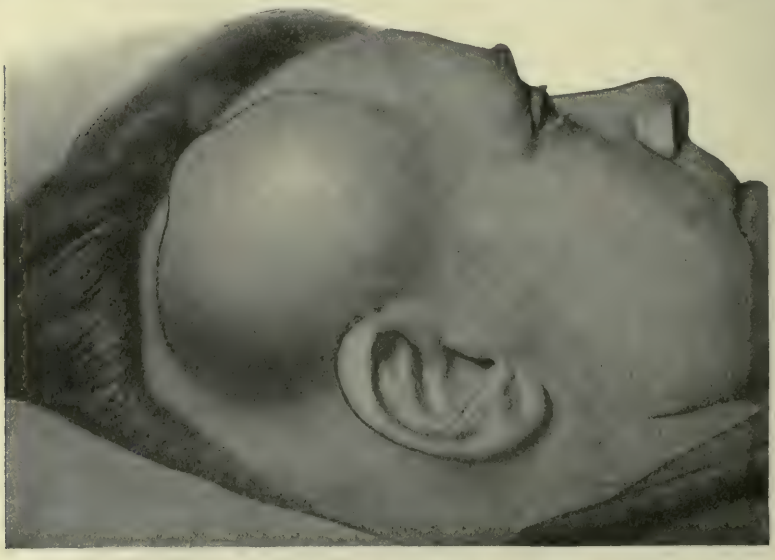


FIG. 136.—An extrinsic sarcoma arising from the bones entering into the formation of the temporal fossa.

like all gummata, they are prone to break down, the skin giving way, leaving an ulcer with sharp-cut, undermined edges and a dirty wash-leather base. Bare bone may be felt or seen. The exposed bone derives part of its blood supply from the pericranial vessels, and the loss of this, together with the secondary pyogenic infection, aggravates the disease in such a way as to produce necrosis of part of the bone involved.

In some cases the exposed external table exfoliates, first blackening by exposure to the air and then separating, leaving an ulcer which may heal. In others the diploic tissue is involved (osteo-periostitis), with perhaps some new formation of bone but with considerable areas of necrosis. In the most serious type the whole thickness of the skull may be destroyed, leading to prolonged suppuration, with its attendant dangers of intracranial complication, meningitis, cerebral abscess, etc.

The destructive action of the spirochæte is usually accompanied by a certain degree of regeneration—that is to say, by a certain amount of new bone

formation. In consequence, syphilitic skulls are rather thicker and heavier than the normal variety. It is by reason of these changes that a syphilitic skull is capable of being diagnosed from a tuberculous one. In the latter case there is no new bone formation.

Even in the worst cases healing may take place, after the exfoliation of the necrotic bone, with a puckered and depressed scar, perhaps adherent to the exposed dura mater.

*Treatment.*—This should be carried out in accordance with the general principles of anti-syphilitic treatment. Necrotic bone is removed as soon as it is free.

**Tuberculosis of the skull.**—This disease is seldom seen except in the young, and then usually as a manifestation of a more generalised infection. The process generally commences as a caries of the diploic tissue, tending to spread externally, with the formation of a soft fluctuating swelling. It shows a considerable tendency to break down, leaving an ulcer with undermined edges, and a pale, unhealthy base, which discharges a thin purulent fluid. In addition, the soft swelling may be connected with the surface by means of numerous sinuses. When these are probed, bare bone is encountered. There is also considerable tendency to secondary infection of the brain and meninges.

The *prognosis* is unfavourable, the disease spreading to the meninges or the patient succumbing to a more generalised tuberculosis.

*Treatment.*—All sinuses are slit up to their termination, carious bone is scraped away with a Volkmann's spoon, and the whole area packed with gauze and allowed to granulate from the bottom. Dead bone is removed when occasion demands.

## Tumours of the Skull Bones.

**Exostoses,** and the more rare *enostoses*, are the only innocent tumours arising directly from the bones of the skull. *Exostoses* develop only in certain situations —at the external angular frontal process, over the frontal and parietal eminences, in the external auditory meatus and in relation to the mastoid process (see also p. 463). A comparison between these exostoses and those arising in connexion with the long bones tends to show that the exostoses of the skull develop in connexion with the sites of primary or secondary centres of ossification, regions in which the activity of growth is long maintained.

*Enostoses* are found along the median antero-posterior line, in relation with the Pacchionian bodies of the superior longitudinal sinus. They seldom give rise to pressure symptoms, and are usually discovered accidentally in the post-mortem room.

Exostoses are either cancellous or "ivory." The last-named type occurs mainly in the fronto-parietal region as flat or slightly-pedunculated tumours. They increase slowly in size up to a certain standard and then enter on a quiescent stage. The cancellous variety occurs with the greatest frequency in relation to the frontal sinus, though it is also seen in connexion with the auditory meatus. They increase in size along the line of least resistance, tending to fill up the frontal air sinus, the middle and external ears, etc. In addition to the possible blockage of these spaces, with attendant dangers of empyemata, etc., the growth may paralyse nerve trunks with which it comes into contact, *e.g.*, the facial nerve.

Again, in the event of the orbital cavity being involved, the globe becomes proptosed in a direction downwards and outwards. Strabismus, diplopia, and corneal sloughing may occur.

*Treatment.*—In the event of development of definite pressure symptoms,

and from the cosmetic point of view, these exostoses must be removed. The operation may be formidable, the attachments of the tumour being broad, the bone hard, and the surrounding structures of such importance as to require delicate manipulation. As an additional argument for early operative treatment it is clear that certain of these exostoses may undergo degenerative changes, malignant or otherwise.

**Malignant tumours** include both primary and secondary sarcomata, secondary carcinomatous growths, and tumours of a mixed nature arising in connexion with disease of the thyroid and suprarenal bodies. With respect to secondary carcinoma the primary source is usually to be found in the breast, prostate, testicle or ovary.

Primary sarcoma, a rare disease, usually arises from the pericranium, appearing as a firm, broadly-attached tumour, more commonly situated in the temporal region. There is no pain attached to the disease in its earlier

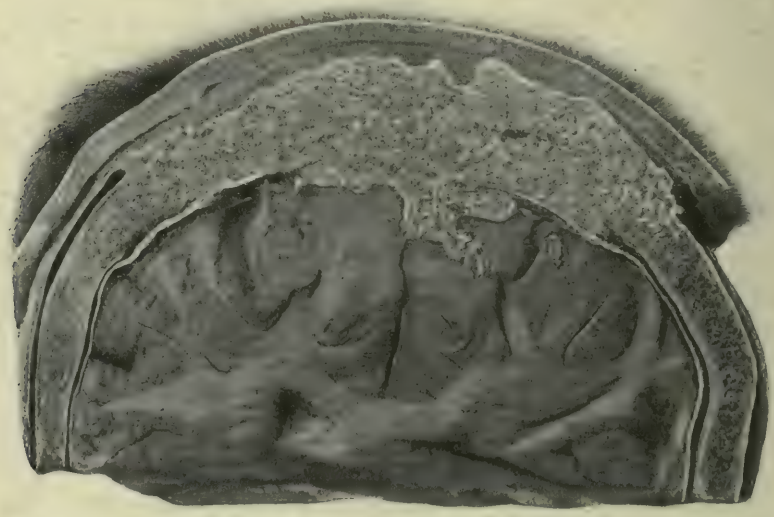


FIG. 137.—Intrinsic sarcoma of the skull with invasion of membranes and cortex. (St. Bartholomew's Hospital Museum.)

stages. The tumour grows rapidly, ulcerating through the integument and extending, at the same time, in the inward direction.

*Treatment.*—If recognised early a primary sarcoma should be removed, together with the whole thickness of the bone to which it is attached, a wide margin of healthy bone being removed too. The gap in the skull may be protected with a silver plate (see p. 440). The *prognosis* is bad, secondary growths appearing in most cases within a few months of removal.

For the various secondary carcinomatous and other malignant growths no treatment is of any avail.

## Fractures of the Skull.

Fractures of the base are more common than fractures of the vault, and, even when the two conditions are combined, the vault fracture is often secondary to, and a mere extension from, the basic lesion. Consequently it will be convenient to commence with *fractures of the base.*

**Fractures of the base.**—Whenever entering into the question of the mechanics of basic fractures and the symptoms observed in such cases, every attention must be paid to the anatomical structure of the basic fossæ, more especially with reference to the weaker areas or areas of lesser resistance. They are conspicuous and readily appreciated on trans-illumination of the skull. Then it will be seen that the anterior fossa, the territory of the middle

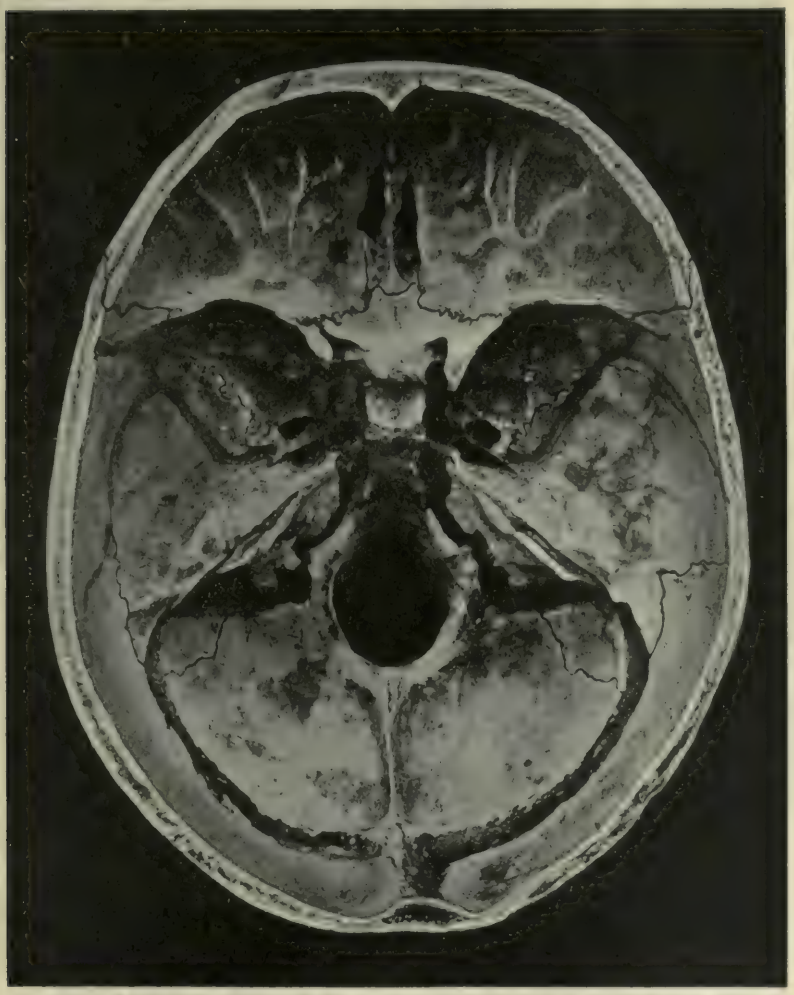


FIG. 138.—The base of the skull, showing the three fossæ, the foramina, the groove for the middle meningeal artery, lateral sinus, etc.

meningeal artery, and the cerebellar fossæ are obviously thinner and weaker than any other part of the skull, this translucency resulting in the main from the absence of diploic tissue in the regions mentioned. It is at once clear that fractures are more likely to involve these parts in preference to other regions. Again, not only are the basic foramina sources of additional weakness, but there are certain regions which at first sight appear unusually strong, but which in reality are but poorly adapted for the reception of blows. Thus,

the basi-sphenoid is hollowed out for the reception of the great sphenoidal air sinus, a mere shell of bone enclosing the same, whilst the apparently strong petrous bone is occupied in the main by the various parts of the auditory apparatus.

Still, although the base presents certain elements of weakness, there are compensatory buttresses intervening between the weaker regions. The more

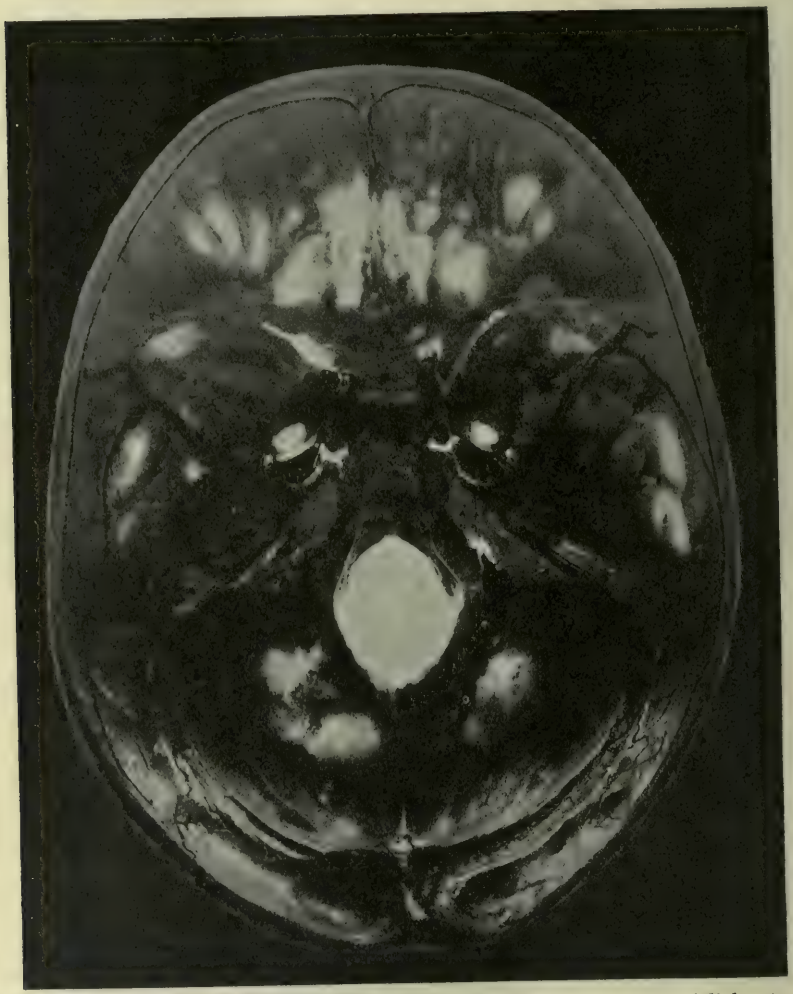


FIG. 139.—The same specimen as Fig. 138, viewed with transmitted light, to show the various weaker areas.

important of these " ribbings " are as follows :—The internal occipital crest, the lateral sinus ridges and the strengthened margins of the foramen magnum (posterior fossa), the upper border of the petrous bone (middle fossa), and the frontal crest, the crista galli and the strengthened posterior border of the lesser wing of the sphenoid (anterior fossa). It is mainly along these ridges that forces applied to the vault are conducted to the base, diminishing in strength as they advance and finally buffered or damped at the termination of the " ribbings," at the anterior and posterior clinoid processes, apex of

petrous bone, etc. To these bony points the membranes of the brain are attached, and it is probable that these membranes assist in the reception and transmission of the forces conducted thereto.

On applying these mechanical points to clinical experience it will be seen that the great majority of basic fractures do follow certain definite paths and that these paths are the weaker lines of the base. Thus, for example, there is one fracture of the base which is of such common occurrence, either in whole or in part, that it has been named the "*typical*" fracture of the base. This fracture extends from one auditory region to the other, not directly, but passing immediately anterior to the petrous bone towards and through the "body" of the sphenoid, then being directed backwards again along the front aspect of the other petrous bone and terminating in the opposite middle and

FIG. 140.—Antero-posterior section of the skull, showing the foramina, grooves for middle meningeal artery, pituitary fossa, etc.

external ears. On investigating this particular fracture with relation to weak and strong basic regions it will be seen that the fracture passes across the external and middle ears, along the petro-sphenoidal suture (or what remains of it), across the foramen lacerum medium, and then over the middle line through the sphenoidal air sinus. In other words, the fracture, in its general direction, pursues the line of least resistance.

Other basic fractures show similar propensities, tending to follow certain definite paths, guided by the same general conditions, and traversing the base in the general direction of the applied force. Thus, most anterior fossa fractures involve the weak cribriform plate of the ethmoid bone and the thin orbital plates of the frontal, and most fractures of the posterior fossa follow an equally definite course. In the last-named case the basic fracture is sufficiently constant in direction to require further description. In the

majority of cases the fracture passes across the weak cerebellar fossa towards the foramen magnum, striking that foramen immediately posterior to the condyle. It is continued again on the other side of the foramen, starting behind the condyle of the occipital bone, and cutting across the jugular foramen, then traversing the petrous bone in the antero-posterior direction and terminating in the region of the middle ear.

Though there are unquestionably certain defined paths which are followed by basic fractures when occasion permits, yet it is also quite clear that, in some cases, owing probably to the excessive violence applied, the fracture traverses the base regardless of all anatomical considerations. In addition, allusion should be made to a distinct type of fracture which results from heavy falls on to the buttocks or feet. In such cases the weight of the body,

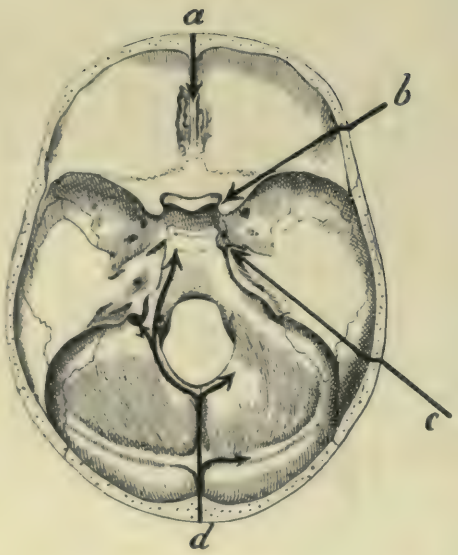
FIG. 141.—Antero-posterior section of the skull on trans-illumination, to show the weakness of the "middle meningeal territory."

being transmitted through the condyles of the occipital bone, produces a "*ring-shaped*" fracture of the parts entering into the formation of the foramen magnum.

With these preliminary remarks it remains to discuss briefly the mechanism of basic fractures in general. This is not an easy matter, for there are several theories, no single one of which is acceptable for all cases. These theories are as follows :—

*Aran's irradiation theory.*
*The contre-coup theory.*
*The bursting and compression theories.*
*The direct injury theory.*

*Aran's irradiation theory.*—"Fractures of the base result as extensions from fractures of the vault, the fracture following the shortest anatomical




(*a*) Illustrating the lines along which forces received on the vault are transmitted to the base.

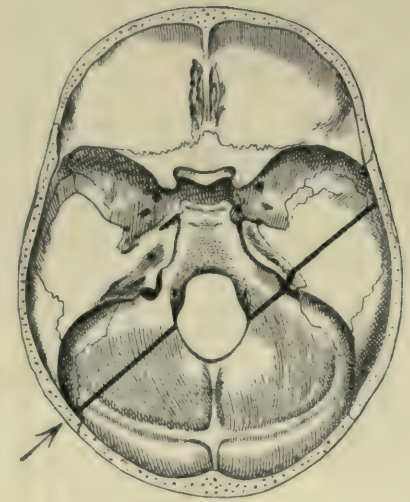
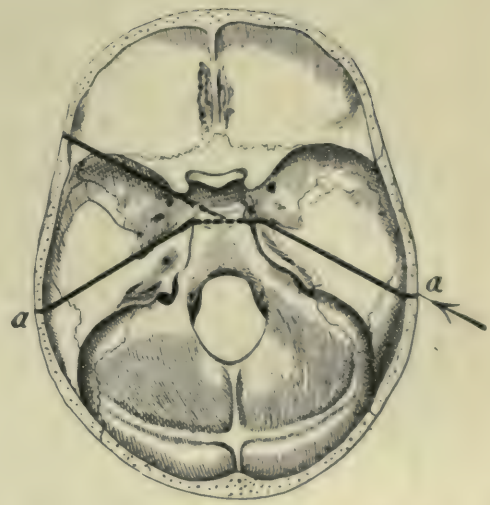


FIG. 142.

(*b*) Illustrating the course pursued by a basic fracture, the blow being applied to the lateral occipital region.




(*c*) Illustrating the course pursued by a basic fracture, the blow being applied to the lateral temporal region.
*aa*, the " typical " basic fracture.

route to the base "—in other words, all basic fractures are regarded as secondary to, and as extensions from, a primary vault fracture. There can be no doubt that some basic fractures are mere secondary manifestations, but, on the other hand, many fractures of the skull are confined to the base alone, and in numerous other instances the site at which the blow has been applied and a comparison between an unimportant fissured fracture of the vault and an extensive basic lesion prove conclusively that the fracture of the base was the primary and main lesion. Aran's law, therefore, can only be accepted as applicable to a certain, and small, proportion of cases.

*The contre-coup theory.*—" From the point struck a wave is transmitted through the semifluid brain producing a fracture at some more distant point." It is impossible to believe that the semifluid brain and cerebro-spinal fluid could produce a wave of such volume and momentum as to bring about a fracture of the bone at some more distant region. This theory may be rejected *in toto*.

*The bursting and compression theories.*—The skull is regarded as an elastic sphere, compression of which leads to diminution in the diameter along the axis of pressure, bulging occurring in other diameters. The bulging exceeding the limits of elasticity, a fracture occurs. When the line of fracture runs parallel to the direction of the compressing force, the bone bursts open along the convexity (*bursting fractures*), and when the line of fracture runs at right angles to the direction of the compressing force, a fracture by compression is said to result (*compression fractures*).

This " bursting and compression " theory probably accounts for those fractures of the skull which are produced by bilateral compression, the skull being squeezed between two objects. As, however, but a small proportion of fractures are produced in this manner, and as the elasticity of the skull, requisite for the acceptance of the theory, is, to say the least, a most debatable point, this theory cannot be generally accepted.

*The " direct " injury theory.*—In examining this theory two points require acceptance—first, that the great majority of basic fractures result from falls or blows in which the force is applied near the level of the base (occipital region, over the mastoid and external angular frontal processes, and in the region of the superciliary ridges), and, secondly, that the base is weaker than the vault. These two points being facts, a large percentage of basic fractures may be regarded as *direct* fractures, the force traversing the base and splitting it much in the same way as a chisel splits a board of wood, the grain of which may be regarded as equivalent to the lines of lesser resistance of the base and any intervening " knot " as one of the stronger buttresses of the base. Thus, a fracture ought to traverse the base in the general direction of the applied force, but not necessarily in the same straight line throughout—the fracture may be momentarily turned aside from its original course by some obstruction, regaining its original direction at the first opportunity.

A general examination of basic fractures does show this peculiarity, and it can be seen that, when opportunity allows, the majority pass along certain definite paths, these varying directly with the site of application of the force and its direction.

As a summary of theories, it would appear that *Aran's theory of irradiation* and the *bursting and compression* theory account for some fractures of the base, but that the greater number are *direct* fractures, the force being applied near the basic level and traversing the base in preference to the stronger vault.

There are also other *direct* fractures of the base, such as are brought about

by perforating wounds through the orbit, up the nose through the cribriform plate, and bullet wounds through the roof of the mouth.

*The symptoms observed in fractures of the base.*—Whatever fossa be involved, the following symptoms require consideration :—

1. *Hæmorrhage.*
2. *Escape of cerebro-spinal fluid.*
3. *Escape of brain matter.*
4. *Escape of air from the air sinuses into the overlying tissues.*
5. *Involvement of nerves.*

*Clinical signs of fracture through the anterior fossa.*—1. **Hæmorrhage.**—The fracture involves the cribriform plate of the ethmoid, or the orbital plates of the frontal bone, or both. When the ethmoid is involved, bleeding occurs from the nose, perhaps also from the mouth, the blood trickling down the naso-pharynx. When the fracture passes through the orbital plates, there is effusion of blood into the lids (palpebral and peripalpebral hæmorrhage), underneath the conjunctiva (subconjunctival hæmorrhage), and into the tissues of the orbital cavity, producing proptosis and squints through mechanical impediment to the action of the ocular muscles.

2. **Escape of cerebro-spinal fluid.**—A fracture comminuting the cribriform plate of the ethmoid may so tear the prolongations of dura and arachnoid around the olfactory nerves that the subarachnoid space is opened up to the exterior. In consequence cerebro-spinal fluid may escape down the nose. At first the fluid is mixed with blood, but in a few hours it may become clear and may be collected in a test-tube and examined. It presents the ordinary characteristics of cerebro-spinal fluid, being like water in appearance, having a specific gravity of about 1,005, and, when examined chemically, showing a trace of albumen, a fair quantity of chlorides, and a reducing substance allied to pyrocatechin. The fluid soon loses these characteristic features and becomes a mere serous discharge. This is explained by the fact that but very little cerebro-spinal fluid is normally secreted, and as soon as the original amount is lost, its place is taken by a serous exudation from the cerebral sinuses and veins. If the patient recovers, the fluid escapes in a decreasing quantity and finally the discharge stops.

3. **Escape of brain matter.**—In the event of considerable comminution of the cribriform plate of the ethmoid, together with tearing of the membranes of the brain and laceration of the frontal lobes, pulped or disintegrated brain matter may be forced into the nose and escape by the nostrils.

4. **Escape of air from the air sinuses.**—If the fracture involves the outer wall of the frontal sinus, sneezing or forcible blowing of the nose may force air out of the sinus into the overlying tissues, with the formation of a frontal pneumatocele or surgical emphysema (see p. 398). In both cases the swelling gives the characteristic crepitation of an air-containing swelling.

5. **Involvement of nerves.**—Injury to the olfactory nerves results in loss of smell (anosmia), and the optic nerve may be compressed or lacerated in the region of the optic foramen, with impairment of vision in direct proportion to the degree of injury. The motor nerves of the eye—third, fourth, and sixth—are also liable to irritation or compression, either as the result of hæmorrhage into the tissues of the orbit or of direct compression as they pass through the sphenoidal fissure. Alterations in the size of the pupil and squints result. The first division of the fifth nerve and its branches may be injured in the same situations, with hyperæsthesia or anæsthesia, according to the degree of injury.

*Clinical signs of fracture through the middle fossa.*—1. **Hæmorrhage.**—The fracture usually passes across the external and middle ears and the membrana tympani is lacerated. There is, in consequence, bleeding from the external auditory meatus, sometimes quite slight, at others very profuse. The more serious the hæmorrhage and the longer it is continued, the more probable is it that the basic lesion is complicated by an extradural hæmorrhage from the posterior branch of the middle meningeal artery, this vessel

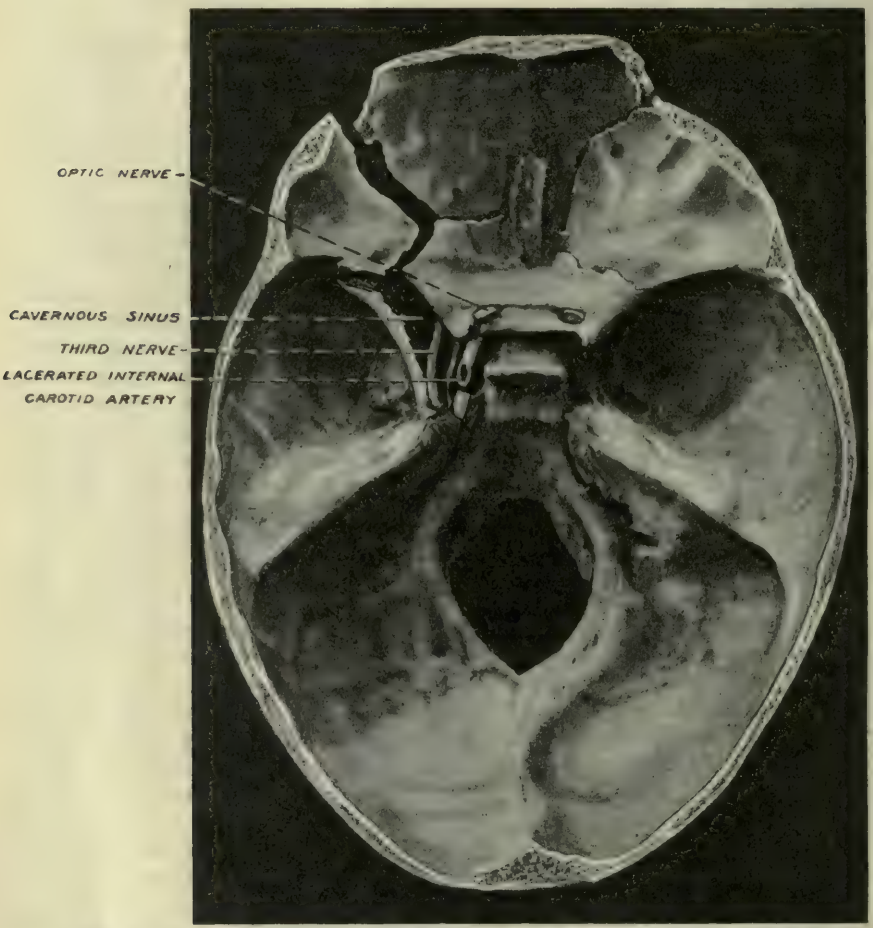



FIG. 143.—An extensive fracture of the anterior fossa of the skull, with laceration of the cavernous sinus and of the internal carotid artery. (St. Bartholomew's Hospital Museum.)

passing backwards in direct relation to the roof of the middle ear. In the event of such a lesion the effused blood is forced into the middle ear through the rents in its roof and escapes freely by the external meatus. Bleeding also takes place from the nose and mouth, for the very great majority of middle fossa fractures involve the sphenoidal region, perhaps with injury to the cavernous sinus or internal carotid artery. The blood escapes freely into the naso-pharynx and so externally by the nose or mouth. A considerable quantity may be swallowed, to be vomited up later.

2. **Escape of cerebro-spinal fluid.**—Cerebro-spinal fluid may escape from the ear. Such a discharge implies considerable comminution of the petrous portion of the temporal bone, with laceration of the dural and arachnoid prolongations of the facial nerve and the opening up of the subarachnoid space to the exterior. The discharge may be profuse. In other respects the fluid, in its flow and character, follows the rules mentioned above.

3. **Escape of brain matter.**—For the escape of brain matter from the ear it is necessary that the petrous bone should be extensively comminuted, the overlying membranes torn and the brain (temporo-sphenoidal lobe) severely lacerated.

4. **Escape of air from the air sinuses.** — If the fracture involves the mastoid region, air may escape from the mastoid antrum and cells into the overlying tissues, with the formation of a pneumatocele or of surgical emphysema, according as to whether the air remains localised beneath the periosteum or diffuses widely throughout the cellular tissues.

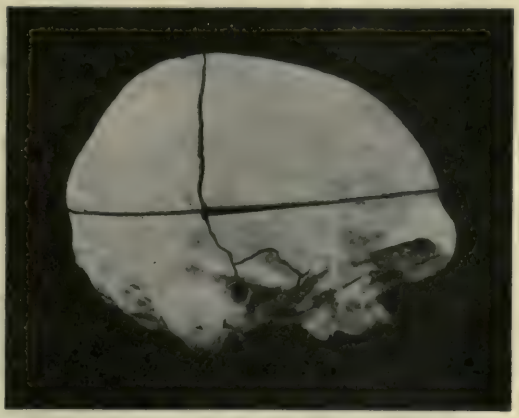
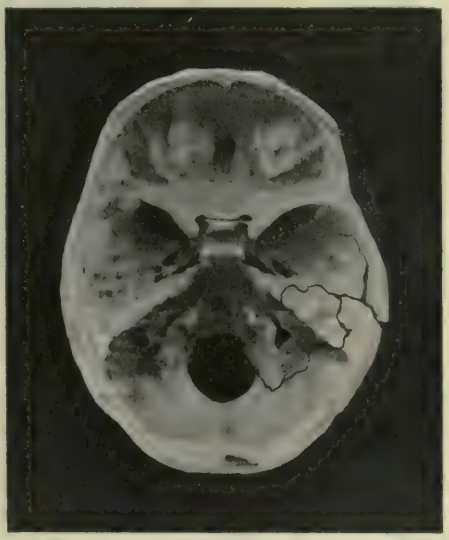


FIG. 144.

(*a*) A combined vault and basic fracture—the extension to the vault.



(*b*) A combined vault and basic fracture—the extension to the base. (St. Bartholomew's Hospital Museum.)

5. **Involvement of nerves.**—The long intrapetrous course of the facial nerve renders it especially liable to injury. Of all nerves involved in basic fractures the facial is the most common. Two types of facial lesion are seen :— First, that resulting from the typical middle fossa fracture which passes through the front part of the middle ear, then along the petro-sphenoidal suture to the sphenoidal sinus region. This fracture, with respect to its exact relation to the facial nerve, is seen to pass immediately anterior to the geniculate ganglion, leaving the internal ear intact. There is, in consequence, paralysis or paresis of the facial nerve, usually temporary in character, together with such deafness as is due to the laceration of the tympanic membrane. In

the second group, as the result of a primary fracture of the posterior fossa in which the fracture traverses the petrous bone in the antero-posterior direction, the facial nerve may be severed and the internal ear so damaged that both permanent facial paralysis and deafness will result.

In addition to the seventh and eighth nerves, the sixth (supplying the external rectus of the eye) is frequently injured, more especially where it is in relation to the dorsum ephipii and posterior clinoid processes, both of which regions are frequently fractured. The third, fourth, and first division of the fifth nerves may be compressed or lacerated at their entry into the sphenoidal fissure, with corresponding squints, etc. The second and third divisions of the fifth nerve are rarely implicated, as the foramen rotundum and foramen ovale are situated anterior to the usual middle fossa fracture.

*Clinical signs of fracture through the posterior fossa.*—1. **Hæmorrhage.**—In this fracture there are no external hæmorrhages with the exception of

FIG. 145.—Elevated fracture, from the cut of a sabre. (Royal College of Surgeons' Museum.)

effusion into the tissues of the occipital and nuchal regions. There is no orifice whereby blood may escape externally. There is also no means of escape for *cerebro-spinal fluid* or *brain matter*.

2. **Involvement of nerves.**—As previously mentioned, these posterior fossa fractures tend to traverse the petrous bone in the antero-posterior direction, in which case the facial nerve may be divided and the internal ear severed into two parts, with consequent permanent facial paralysis and deafness. The fracture, in its course, also passes across the jugular foramen, and though the glosso-pharyngeal, vagus and spinal accessory nerves are well protected by their dural coats, they may be compressed by blood-clot, with consequent dysphagia, dyspnœa, etc., and sometimes with sudden death (from vagus paralysis). The hypoglossal almost invariably escapes, for the anterior condyloid foramen is not in the usual path of the posterior fossa fracture. The upper cervical nerves may be irritated by the pressure of blood-clot, with stiffness of the neck muscles and retraction of the head and neck.

**Summary of symptoms observed in fractures of the base :—**

| | ANTERIOR FOSSA. | MIDDLE FOSSA. | POSTERIOR FOSSA. |
|---|---|---|---|
| **Hæmorrhages.** | | | |
| | Subconjunctival. | Into the temporal region. | Into the nuchal, occipital and post-auricular regions. |
| | Palpebral. | | |
| | Orbital. | From the mouth. | |
| | From the nose. | From the nose. | |
| | From the mouth. | From the ear. | |
| **Cerebral-spinal fluid.** | | | |
| | From the nose. | From the nose. | None. |
| | From the mouth. | From the mouth. | |
| | | From the ear. | |
| **Brain matter.** | | | |
| | From the nose. | From the ear. | None. |
| **Escape of air.** | | | |
| | From the frontal sinus. | From the mastoid antrum. | None. |
| | From the ethmoidal cells. | | |
| **Nerve involvement.** | | | |
| | Olfactory. | Sixth. | Seventh. |
| | Optic. | Seventh. | Eighth. |
| | Third. | Eighth. | Ninth. |
| | Fourth. | | Tenth. |
| | First division of fifth. | | Eleventh. |
| | Sixth. | | |

**Fractures of the vault.**—A fracture may be confined to the vault or it may be associated with a basic fracture. In the former case the fracture commonly results from the application of a violent blow to the vertex of the skull with a sharp or rounded weapon. Perhaps the most frequent cause of a fractured vault is the falling of some weight from a height on to the top of the head. According to the strength of the skull and the violence applied, the fracture is simple or compound, with or without depression of fragments, fissured, stellate, comminuted, punctured or elevated—terms which explain adequately the nature of the lesion. Elevated fractures are due to the effect of a glancing blow, sabre cut, bullet, etc.

In the great majority of cases the whole thickness of the skull is involved, and in all such cases the internal table suffers more severely than the external. Indeed, the internal table may be fractured without there being any lesion of the external. This is not due to the supposed greater brittleness of the internal table, but is in obedience to Teevan's law, which states that " when pressure is applied to a body the fracture commences on the line of extension, not that of compression."

*Signs and symptoms.*—A fracture of the vault is not always easily diagnosed. In compound cases digital examination of the wound, after thorough preliminary cleansing, will soon determine the extent of the injury. In the event, however, of the scalp remaining intact, and more especially if the case is not seen at once, extensive hæmatomata, subaponeurotic and subpericranial, will tend to obscure any fracture that may exist. In cases of this nature one is forced to rely on the general symptoms, such as are dependent on injury to intracranial vessels and to the brain.

Again, a fracture of the vault does not present any great elements of danger unless it is complicated—as is so frequently the case—by injury to meningeal vessels, cerebral sinuses and brain.

The *treatment* of fractures of the vault is considered later. It will, however,

be convenient at this point to state as definitely as possible that every fracture of the vault, whether simple or compound, should be explored unless one is certain that there is no depression of bone and no intracranial complication. Thus, every depressed fracture should be examined, the depressed fragments elevated into position, and all particles of bone which have been driven through the dura mater removed. Again, every simple fissured fracture which is complicated by such intracranial mischief as produces symptoms of compression urgently demands operative treatment. The details and technique are dealt with later.

When the fracture is confined to the internal table, a diagnosis is seldom possible in the early stages unless the middle meningeal artery has been injured, in which case the symptoms resulting from the extradural hæmorrhage will assist in the diagnosis. Later on, however, a more certain diagnosis can be made in the presence of chronic fixed pain at the seat of the injury, chronic headache, or fits of a Jacksonian type.

FIG. 146.—Fracture, inner table of vault of skull. (St. Bartholomew's Hospital Museum.)

From these few preliminary remarks it will appear that a fracture of the vault is frequently diagnosed by a consideration of the signs of intracranial complications directly brought about by the depression of bone. Of these complications middle meningeal hæmorrhages and extravasations of blood from torn cerebral sinuses are sufficiently definite in their symptoms to be treated separately. On the other hand, injury to the brain is by far the most common complication, with its attendant symptoms of *concussion*, *irritation* and *compression*.

**Injury to the brain.**—This is by far the most serious of all the various intracranial complications arising in fractures of the vault or base. On its presence or absence the result virtually hinges. The lesion varies in degree from a slight bruising of the brain, evidenced by some minute cortical hæmorrhages and a sero-sanguineous exudate in the meshes of the pia-arachnoid, to extensive laceration, and even pulping, of a certain portion of the cerebral substance. In cortical lacerations there is, in addition, considerable bleeding into the subdural space, sometimes forming a coagulum, but always tending to gravitate to the base. The effusion is usually dark in colour, and is derived in the main from lacerated cerebral veins. Any part of the brain may be injured, but there are two regions in which laceration is especially prevalent, the anterior and inferior aspect of the frontal lobes and the anterior pole of the temporo-sphenoidal lobe.

The region injured is largely dependent on the site at which the blow is applied. There is bruising or laceration over the cortex immediately in relation to the site of the application of violence and also on the opposite side of the brain in the line of the forces transmitted through the brain substance. When laceration occurs on the opposite side of the brain it is regarded as being of the nature of laceration by *contre-coup*, the soft cerebral substance being brought into violent contact with the opposing skull wall. In both cases the area injured is more or less cone-shaped, the apex towards the central portion

of the brain, and the base on the surface. It is from this lacerated surface that considerable hæmorrhage takes place into the meshes of the pia-arachnoid and into the subdural space.

## Brain Injury.

Though a localised lesion of the cortex may bring about certain definite *localising* symptoms, varying of course according to the region involved, yet experience shows that it is the rule for such symptoms to be obscured, at any rate in the earlier stages, by the symptoms of *concussion*, *irritation* and *compression of the brain*. Of these three concussion is the primary condition. It is fairly certain that every case of serious head injury is primarily concussed, and that cerebral irritation and compression are secondary manifestations, dependent on certain local conditions which will be enumerated later.

**Concussion (cerebral shock).**—The patient lies more or less unconscious, with a pale face and a cold and clammy skin. The limbs are flaccid and all reflexes are abolished, with the possible exception that the corneal reflex may be retained in the slighter types of concussion. The pupils are dilated, equal and generally responsive to light. The temperature is markedly subnormal, the respiration shallow and the pulse accelerated in rate but diminished in tension. Both urine and fæces may be passed involuntarily. This is the *first stage of concussion* or *the stage of shock*. If the patient recovers, and is watched throughout, it will be seen that, after a variable period of time, there is a gradual transition from this primary stage into the *second stage* or *stage of reaction*, the change being heralded by vomiting. In this second stage the patient is again conscious, exceedingly restless and complaining of violent headache. The pupils are contracted, the temperature raised, the skin hot and respiration deep. The pulse, sometimes accelerated, sometimes slowed, is of high tension. All reflexes tend to be exaggerated.

The two stages of concussion last a variable period of time. Sometimes the patient gets perfectly well within a day or two and suffers from no after-effects whatsoever. At others the stage of reaction gradually merges into that of cerebral irritation or definite compression. In still another group the patient remains obstinately concussed and may die in that condition. In fact, it is often quite impossible to foretell with any degree of certainty what course will follow the primary stage of cerebral shock.

From this it is obvious that concussion is a clinical condition dependent in its severity and duration on some exciting cause, and it is usually stated (1) that every case of concussion is associated with, and dependent on, associated injury to the brain, and (2) that the depth of the concussion is directly proportional to the extent of the injury and the degree of intracranial hæmorrhage. There is every reason to believe that the second of these two statements is correct, but considerable doubt may be expressed as to the truth of the first. It is difficult to accept the statement in view of the fact that many mild cases of concussion are discharged from treatment within a day or two, and that they suffer from no after-effects whatsoever. It would appear highly improbable that they could have experienced so serious an injury as cortical bruising, etc.

Many theories have been advanced as to the *pathology* of concussion. Some regard it as evidence of a molecular disturbance of the brain cells, others consider that the symptoms are referable to the effect of a fluid wave exercising a deleterious influence on the basal ganglia and corpora quadrigemina. On the whole, the most satisfactory explanation is the following :—Concussion is a clinical condition resulting from paralysis of the vaso-motor centre. This centre has one main function—to keep up blood pressure. As the result of

sudden paralysis there is a great fall in blood pressure, an accumulation of blood in the abdominal veins. The cerebral circulation, possessing no separate vaso-motor apparatus, passively follows the changes in the general circulation. In consequence, there is, within the skull, a diminution in the amount of arterial blood (cerebral anæmia) and a more or less proportionate venous hyperæmia—the cranial cavity must contain the same general volume of fluid whatever conditions be existent elsewhere. And again, insomuch as the venous pressure and cerebro-spinal tension are practically equal, and as the venous hyperæmia implies a rise in venous blood pressure, there is an exudation of serum from the veins into the pia-arachnoid region. Therefore, in fatal cases of concussion, one would expect to find engorged veins and an excess of fluid in the subarachnoid space, etc. Such conditions are found.

A consideration of these facts and a comparison between concussion and ordinary surgical shock tends to show that the two conditions are closely allied. In concussion, however, the onset is sudden and the patient is more or less unconscious. These two points of difference, however, are explained by the fact that in concussion the vaso-motor centre is brought to a sudden standstill with acute anæmia of cortical vessels and with consequent loss of power and senses.

The injury being of a mild type the centre soon recovers tone, whilst in the more serious injuries the stage of depression is prolonged in direct proportion to the nature of the intracranial lesions existent.

**Cerebral irritation.**—The stage of concussion may give place to that of *cerebral irritation*. Here the patient lies curled up in bed, the head covered with the arms or hidden in the clothes, the eyes tightly closed through intolerance of light (photophobia). All interrogation and interference are resented, and the patient is in general exceedingly irritable. He complains of violent and persistent headache. The temperature is raised, the skin hot, and the pulse accelerated in rate and of high tension.

Cerebral irritation is unquestionably dependent on bruising of the brain.

As a general rule the irritable state gradually quiets down and a complete recovery may be anticipated. Under other circumstances, more especially when injudiciously treated, it may merge into actual compression.

**Compression.**—In other cases, the symptoms of concussion give place to those of *compression*. The current views with respect to the pathology of compression are based largely on the experiments of Leonard Hill. The compressing agent, wherever localised, produces similar general compression symptoms, these varying in rapidity of onset and intensity according to the nature and site of the exciting cause. Thus, compression from intracranial hæmorrhage is identical with the compression of a brain tumour excepting that in the former case the symptoms are more rapid in onset. Again, a cerebellar tumour brings about symptoms of general compression similar to those resulting from a cerebral neoplasm, except, again, that they are more rapid in onset.

There are of course certain intermediate stages, midway between the stage of concussion and that of fully-developed compression, but when the patient *is* compressed the symptoms are sufficiently definite. He is completely unconscious, quite irresponsive to stimuli. The limbs are in a state of flaccid paralysis and all reflexes are for the time being abolished. The respiration is heavy, deep and stertorous, the cheeks puffing out on expiration through paralysis of the buccinators. The face is flushed and cyanosed, through deficient aeration of the blood. When the respiratory centre becomes paralysed the respiration becomes typically " Cheyne-Stokes " in character.

The pulse-rate is markedly slowed—perhaps to not more than forty beats per minute—and its tension raised up to 250 mms. of mercury or more. Both urine and fæces are passed involuntarily. The pupils vary, but are either equal and dilated or unequal. The temperature is always raised and, in fatal cases, rises progressively till death ensues.

Experimentally it has been shown that from 3 to 6 per cent. increase of intracranial pressure is required to give rise to compression symptoms. The effect of compression on the brain is as follows :—The brain itself is incompressible, but, like a sponge, the fluid constituents are squeezed out ; first the cerebro-spinal fluid, then the veins are compressed, and, the pressure rising still further, next the smaller arteries, until the general intracranial pressure equals that of the smaller arteries. The compression effects are, in all probability, at first local, but they soon become generalised, for there is definite pressure continuity between the supra- and infra-tentorial spaces. For example, the effect of compression exerted over one cerebral hemisphere is soon transferred to the subtentorial region.

The *pathology* and *symptomatology* of compression will be made more clear by quoting from Kocher, who describes the stages of compression in the following manner :—

*Stage of compensation.*—A mild degree of compression insufficient to compromise the general circulation. Cerebro-spinal fluid escapes into the spinal canal and some of the venous radicles are compressed. Some venous engorgement. Some headache, possibly some focal symptoms. Some mental dulness.

*Stage of beginning compression.*—Beginning failure of the circulatory compensation. Headache pronounced ; vertigo, restlessness, excitement or delirium. Objective symptoms of venous stasis—dilatation of the veins of the eye, both external and internal ; œdema of the disc. Affection of the medullary centres, shown by a slowed pulse and a slight rise in temperature.

*Stage of fully-developed compression.*—Widespread capillary anæmia. Medulla affected markedly. The period of vaso-motor regulation has set in with its high blood pressure, and this, with its vagal quality, gives the pulse its bounding character. The rise of blood pressure shows a definite rhythm. There is also rhythm in respiration, which may acquire the Cheyne-Stokes character. Rhythmic alterations in the size of the pupil, with alternate increase and decrease in the depth of stupor, so that the " up wave " causes the patient to moan, become irritable, and thrash about, whilst the " down wave " sees him completely comatose. Pulse is markedly slowed, and the optic discs show pronounced " choking." Reflexes are abolished, cyanosis extreme, respiration snoring.

*Stage of paralysis.*—Irregular cardiac and respiratory efforts ; pulse grows rapid, coma deepening, muscular relaxation, pupils widely dilated, and permanent fall in blood pressure ; respiratory paralysis.

Before leaving the question of compression it will be advisable to enumerate briefly the points on which assistance may be obtained in the *differential diagnosis* between the coma of trauma and other varieties of coma—*e.g.*, alcoholic, apoplectic, diabetic, and post-epileptic, of opium poisoning, and of uræmia.

The previous history of the case, though often useful, may be misleading. For instance, a patient may fall and injure his head in a stroke of apoplexy. In all cases a complete examination must be made. Even then, doubt may exist as to the particular form of coma present. In such cases a careful watch must be maintained till further evidence is to hand.

The *skull* is examined, both vault and base, for signs of external injury, hæmorrhage from ears, nose, mouth, etc.

The *eyes* come next, being investigated for the palsies of injury and apoplexy, for the hæmorrhages of injury, and the discs for albuminuric retinitis, papillœdema and atrophy (diabetes and uræmia), retinal hæmorrhages (injury).

The *pupils*.—Equal, dilated, but responsive to light in concussion. Equal, but contracted in cerebral irritation. Equal and dilated, or unequal, in compression. Dilated and irresponsive to light in the deeper stages of alcohol poisoning. Dilated and fixed, or unequal, in apoplexy. Pin-point in pontine hæmorrhage. Equal and responsive in epilepsy. Contracted in opium poisoning. Dilated and sluggish in uræmia. Equal but dilated in diabetes.

The *tongue* should be examined for the biting of Epilepsy, the *breath* for Alcohol, the sweetish odour of Uræmia, the peculiar smell of Opium, the chloroform-like smell of Diabetes.

The *face* may be suggestive. The unilateral paralysis of injury and apoplexy, the stertorous respiration, puffing out of the cheeks and general turgidity of traumatic compression, uræmia, apoplexy and deep alcoholism; the quiet breathing and pale face of concussion, opium poisoning, and of post-epileptic and diabetic coma.

The *urine* is examined for albumen and sugar, and the *extremities* for œdema.

The *extremities* are further investigated for unilateral palsy, a condition present in apoplexy and trauma. General convulsions point to injury, uræmia and epilepsy. Resistance to manipulation is suggestive of alcoholic excess.

The *pulse-rate* and the *state of the arteries* may supply valuable evidence. The coats may be atheromatous, whilst the slow, full pulse is strongly suggestive of compression, apoplexy and alcoholism.

A rise of *temperature* is suggestive of brain injury, apoplexy, and alcoholism. In opium poisoning, uræmia and epilepsy it is more likely to be normal or subnormal. In pontine hæmorrhage, hyperpyrexia is the rule. Some difference in the temperature on the two sides of the body suggests injury or apoplexy.

The *depth of the coma* is of great assistance. In concussion, alcohol poisoning, and in the lesser grades of epilepsy and uræmia the patient may be aroused on the application of strong stimuli. In compression, in the deeper stages of alcoholic poisoning, in uræmia and diabetes, and in the status epilepticus the patient cannot be aroused from the deep coma into which he has fallen.

Finally, *lumbar puncture* is of the greatest assistance in the diagnosis. The presence of blood intimately mixed with the cerebro-spinal fluid is strongly suggestive of trauma, and more especially of a subdural extravasation.

**Localising symptoms of brain injury.**—As previously stated, all localising symptoms are liable to be lost in the general picture of concussion and compression. Still, in some cases, they are apparent. Loss of smell (anosmia), from injury to the olfactory bulb and tracts, and impairment of vision, from lesions of the optic fibres, are unlikely to be capable of verification until the patient has fully recovered his faculties. On the other hand, injury to the motor areas is sometimes capable of diagnosis. Bruising may so irritate the cortex as to evoke fits confined to the opposite side of the body, whilst more severe grades of injury may result in contra-lateral paralysis. In addition, injury on the left side of the brain may induce motor aphasia.

The *pupils* and *temperature changes* also require consideration in their relation to injury to the brain. A severe lesion of the cortex in the posterior part of the second frontal convolution may lead to contraction of the *pupil* on the same side and dilatation on the opposite one. On the whole, however, inequality of pupils, though common in all varieties of intracranial

lesion, is of very little value from a localising point of view—there are too many factors entering into the question.

The **temperature** changes in head injuries are very important, exercising a considerable influence on the question of treatment, as will be seen later. There are four types :—

1. The temperature, at first subnormal, rises rapidly to 104° F. or more, the patient showing all the typical symptoms of compression. These cases are usually fatal.

2. The temperature, at first subnormal, rises to 101° or 102° F. and then "marks time." This is the *crisis* of the case, a subsequent rise indicating the advance of compression and heralding a fatal result, whilst a fall points to probable recovery.

3. The temperature, at first subnormal, rises to normal or slightly above. These patients recover.

4. The temperature, at first subnormal, remains obstinately in that state, sometimes so low that it can only be registered in the rectum. These cases are usually fatal, the autopsy showing considerable brain injury. There is no reaction, the patient dying "concussed."

Practically all cases of head injury fall readily into one or other of these groups : indeed, the temperature changes are in general so constant that an accurate forecast of the probable result in any given case may be made from the temperature chart alone. Both temperature and blood pressure should be noted every hour, for, as will be seen later, the treatment hinges largely on these factors.

What the temperature changes are dependent on is quite another matter. They are considered as being directly proportional to the degree of brain laceration. Against such a theory, however, the two following facts are to be noted :—Firstly, similar temperature changes are seen wherever the laceration may be, whether anterior or posterior, superficial or deep ; and, secondly, similar changes are observed in fatal cases of head injury in which there has been no laceration of the brain at all.

**Treatment.**—The treatment of fractures of the vault and base is both *special* and *general*—special with reference to external hæmorrhages, discharge of cerebro-spinal fluid and the like, general with regard to concussion, compression, etc.

*Special.*—Both aural and nasal *hæmorrhages* are usually of a sufficiently mild type to require no special treatment for their control. The bleeding will stop of itself, provided that the nasal bleeding is not derived from a torn carotid artery and the aural hæmorrhage from a lacerated middle meningeal. In the former case, fortunately a rare condition, death occurs within a short time. The rather profuse bleeding that takes place from the external auditory meatus when a severe comminution of the petrous bone is complicated by an extradural hæmorrhage from the middle meningeal artery should be treated, not by plugging of the meatus, but by a planned operation for the ligature or control of the bleeding vessel. The blockage of the meatus will only stop up the safety-valve and hasten the process of brain compression. In the ordinary cases of nasal hæmorrhage no special treatment is required. In the aural type the meatus is *lightly* packed with a strip of sterilised gauze, the dressing being renewed every few hours. On no account should the ear be syringed out. Such a procedure tends to drive organisms present in the external ear towards the meninges and brain.

Hæmorrhages into the lids, beneath the conjunctiva and behind the eye, will soon be absorbed if the patient recovers.

The discharge of *cerebro-spinal fluid* from the nose or ear implies the opening up of the subarachnoid space to the exterior. In spite of this fact meningitis

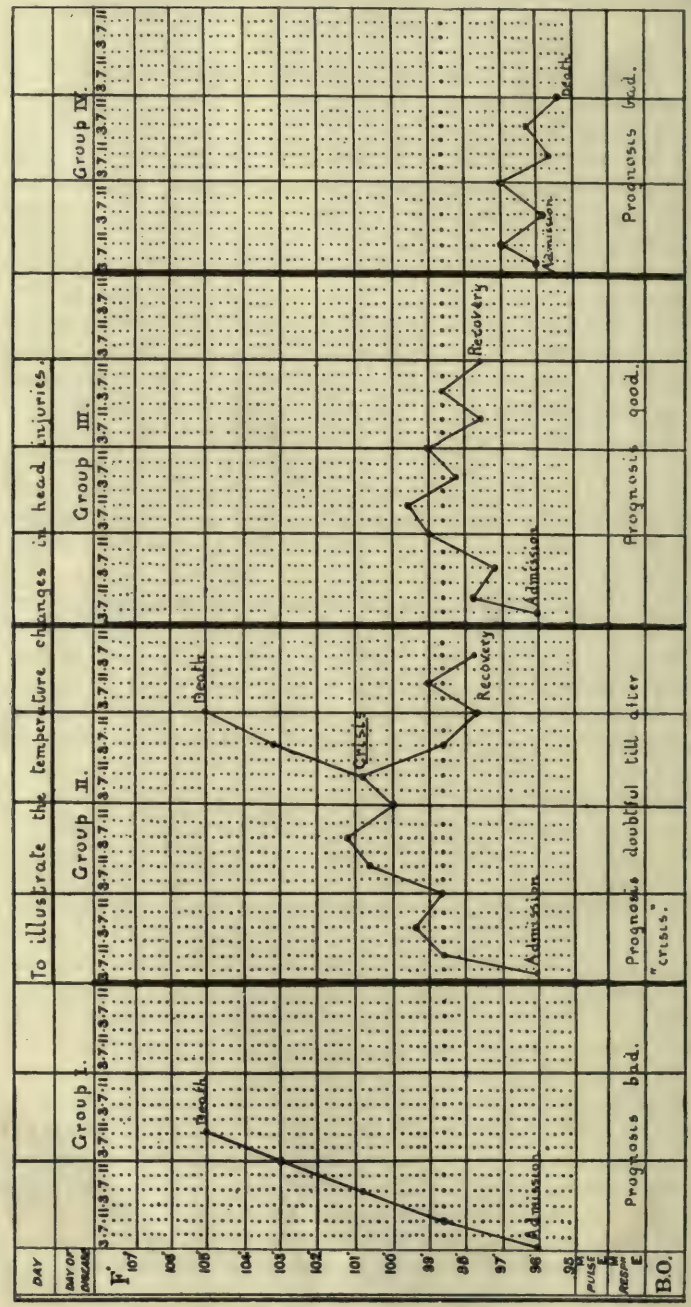



FIG. 147.—Temperature chart to illustrate the four typical conditions observed in head injuries.

is a rare complication. The discharge will soon stop of itself. Nasal discharges require no treatment. In the aural type the meatus is lightly packed with gauze, the dressings being renewed frequently. Under no circumstances

should the ear be syringed out. The danger of a consequent meningeal infection is sufficiently obvious.

The discharge of *brain matter* from the ear or nose implies a severe destruction of bone, laceration of the membranes, and some pulping of the brain. Still, in spite of this, many cases recover without any subsequent ill-effects. The brain matter is wiped away and the ear lightly plugged.

The discharge of *air* from the air sinuses into the overlying tissues usually requires no active treatment. In the event, however, of surgical emphysema, an incision should be made through the tissues and down to the fracture, so as to allow of the direct escape of the air to the surface.

At this point it will be convenient to allude to the administration of urotropin in 10-grain doses, three times in the twenty-four hours, as a routine treatment for all head cases. The drug is excreted within half an hour in the cerebro-spinal fluid, exercising a mild bactericidal effect. It is advisable, therefore, from the prophylactic point of view, to place the patient on routine treatment with this drug. It may be added, as a warning, that urotropin occasionally gives rise to acute irritation of the kidney tubules, with albuminuria and hæmaturia.

*General treatment.*—We now come to the general treatment of cases of head injury—the treatment of concussion, irritation and compression.

1. *Of the milder cases of concussion.*—The patient is put to bed, with the head low; warm blankets are applied to the body and hot bottles to the extremities. A small dose of morphia may be administered hypodermically and 5 to 10 grains of calomel, according to the age of the patient, by the mouth. If, in the course of a few hours, the patient reacts, the head of the bed should be raised and the body only lightly covered. Morphia, or other narcotic, may be required to restrain restlessness, and antipyrin, aspirin, etc., for the relief of the headache. A fluid diet should be given throughout. In the course of a day or two the patient is well.

2. *Of the milder types of compression.*—In the treatment of compression we are on sure ground. The plus pressure must be reduced. In the milder cases, *lumbar puncture, venesection,* and *free purgation* may suffice. Lumbar puncture may be carried out, and, if the fluid escapes at high pressure or is intimately mixed with blood, the process may be repeated. Venesection, though possibly not based on scientific grounds, undoubtedly brings about satisfactory results in many cases. The bleeding is carried out from the median basilic, external jugular or other vein, to the extent of 10 to 20 ozs., according to the age and condition of the patient. During the process of withdrawal a careful watch is maintained on pulse-rate and tension, acceleration of the pulse and lowering of blood pressure indicating that sufficient blood has been removed. Even if this method of treatment induces immediate satisfactory results, the improvement may not be maintained and more radical decompression methods may be required.

3. *Of the deeper types of compression.*—When the temperature is high, the patient deeply comatose, and the blood pressure markedly raised, minor measures are rejected in favour of the more radical. The intracranial pressure must be reduced by decompression operations. Decompression may be conducted, with the greatest measure of certainty, over the cerebellar fossa. The medullary centres, however, appear to resent such radical measures, and the operation of *cerebellar decompression* has rather fallen into disrepute. The *subtemporal operation* appears to present the greater advantages. This operation is carried out over one of the so-called "silent" areas of the brain, the temporo-sphenoidal lobe, an area of brain bruised and lacerated with

greater frequency than any other part of the brain. In addition, the operation is conducted through the middle meningeal territory, that is to say, in the immediate neighbourhood of both branches of the artery. Middle meningeal hæmorrhages, such as give origin to typical symptoms, may be of rare occurrence, but extradural extravasations from that source are exceedingly common, the typical symptoms being submerged in those of concussion or compression. In consequence the operator frequently finds a bleeding meningeal artery, the

FIG. 148.—X-ray photograph of the skull of a patient who had sustained a penetrating gunshot wound of the left temporal region. The aperture in the temporal fossa was enlarged, and a subtemporal decompression carried out in the opposite temporal region for the relief of headache. Numerous foreign bodies scattered throughout the parieto-occipital lobes of the brain and the large bony deficiency are well shown.

existence of which was unsuspected. Furthermore, the operation being conducted through the split fibres of the temporal muscle, any hernial protrusion, such as may result from the increase of intracranial pressure, is adequately protected. In the event of recovery also there is no deformity—the gap in the bone is protected by muscle and the scar is inconspicuous. The details of the operation are given on p. 457.

4. *Of the deeper types of concussion.*—When the concussion stage is prolonged and all ordinary methods fail to bring about the stage of reaction, radical measures must be adopted; otherwise the patient is almost certain

to die. The case is treated after the ordinary principles of surgical shock, by the administration of such drugs as tend to raise the blood-pressure—*e.g.*, pituitary extract and ergot, by the head-down position, bandaging of the limbs, and by saline infusions. Infusions are given by preference *per rectum*, the object being to raise the blood pressure gradually, thus inducing a stage of reaction which can be controlled. Intravenous infusions are very liable, by the more rapid rise in blood pressure, to cause a renewal of the bleeding within the skull. During the process of rectal infusion records ought to be taken every half-hour of both temperature and blood pressure, and in the event of reaction the method should be discontinued. If the reaction becomes too violent, the patient passing directly into the stage of compression, treatment is carried out after the manner described for that condition. This method is a radical one, but, in its general estimation, it must be remembered that death is almost certain to ensue if the patient cannot be brought out of his state of obstinate concussion.

## Gunshot Wounds of the Skull and Brain.

Gunshot wounds of the skull and brain are of the most varied description, but, for all practical purposes, they may be grouped as follows:—

Perforating, or through-and-through, wounds.

Penetrating wounds.

Glancing or gutter wounds.

**Perforating, or through-and-through, wounds.**—A bullet, striking end-on and perforating the skull, may result in small slit-like orifices in the scalp and small bony apertures at site of entry and exit. If, however, the bullet changes position or shape when passing through the head, taking, for example, the "head-over-heels" position, so that the aperture of exit is produced by the long axis of the bullet, the destruction at that aperture will be proportionately more extensive, the brain severely lacerated and a large area of skull blown away. Perforating wounds also, when produced by ricochet or soft-nosed bullets, by shrapnel bullet or shell-fragment, will show severe destruction of the bone at both apertures and great laceration of the brain in the line of the transcerebral track of the missile, with hæmorrhage into the ventricles, at the base of the brain and down the spinal canal.

In the consideration of **penetrating** wounds, it is necessary to bear in mind that the injury to the internal table is almost invariably far more severe than that experienced by the external table. The injury to the external table may appear comparatively trivial, depression of low grade, an aperture quite small, but on exploration it will be found, in almost every case, that the internal table is far more widely and severely injured, with fragments of bone driven through the dura into the brain, and often with injury to the venous sinuses.

This wider and more severe damage to the internal table is due to the fact that the external table is supported by the diploic tissue and internal table, whilst the internal table is altogether unsupported.

Penetrating wounds, also, vary considerably in severity and extent. The least serious are seen when the skull is penetrated but the dura intact. The brain may be bruised, and there may be intracranial hæmorrhage, but the intact dura eliminates, more or less, the possibility of intracranial infection, the main source of danger in all head injuries. The most serious cases are those in which the foreign body and fragments of bone, hair, cap, etc., are driven inwards through the dura mater, perhaps scattered widely throughout

the brain substance, with hæmorrhage into the ventricles and at the base of the brain.

**Glancing, or gutter, wounds.**—In a degree and manner similar to that described above, these tangential fractures are very diverse in degree and severity, varying from a slight gouge in the external table to very severe injuries, in which portions of the skull are blown away. These more severe injuries are dependent, not only on the angle of impact, but also on the rotatory action of the bullet, producing a radiation of forces which act more or less at right angles to the general course and direction of the bullet. Consequently it is clear that a bullet, glancing off the skull, may lead to extensive comminution and depression of the bone, with indriving of bone-fragments and extensive brain injury.

The severity of apparently slight tangential wounds may be easily overlooked unless these facts are borne in mind.

*Signs and symptoms.*—The degree of surface injury depends on the nature of the missile, its shape, velocity and angle of impact. It varies from a small slit, barely visible in the hairy scalp, to the most extensive lesion exposing comminuted bone and lacerated brain. Such head wounds are usually associated with considerable hæmorrhage into the subaponeurotic layer of the scalp, and, in the event of basal complication, with the discharge of blood and cerebro-spinal fluid from nose, ear and mouth.

The *general symptoms* are not necessarily proportional to the actual degree of severity of wound, for patients with very serious head injuries may exhibit, for the time being, little evidence of such an injury. In the majority of cases profound concussion (shock) symptoms predominate, the patient being very collapsed, pallid of face, with cold extremities and surface, subnormal temperature and pulse of high rate and low tension. In the event of considerable intracranial hæmorrhage, before relapsing into unconsciousness, he complains of violent headache, is restless, violent and perhaps maniacal. The more typical symptoms of compression then develop, with unconsciousness, flushed face, puffing cheeks, slow pulse of high tension and stertorous respiration. Later on the collapse stage holds the field, with Cheyne-Stokes respiration and increasing pulse-rate and falling blood pressure.

*Localising symptoms* may be evident, though they are of infrequent occurrence—unilateral flaccid or spastic paralysis, localised fits, etc., on the contra-lateral side of the body.

*X-rays.*—Every case of gunshot wound of the head should be submitted to radiography previous to the undertaking of operative measures. Valuable information will be obtained as to the presence and situation of intracranial foreign bodies.

*Treatment.*—It is now an established fact that operative treatment should be carried out in all cases of gunshot wounds of the skull and brain at the earliest possible moment, if the condition of the patient allows of such treatment. Operation should, however, be postponed if the patient shows severe shock symptoms, and this condition should be combated first of all by means of morphia, quiet, rest and warmth, with, in the most severe cases, the infusion of saline or gum solution, or blood transfusion.

The head should be shaved completely and the scalp wound excised. The scalp wound, the foreign body in the brain and all bone fragments driven through the dura must all be regarded as potential sources of infection. Consequently the operation is carried out along the lines of (1) excision of scalp wound, and (2) removal of all indriven fragments and foreign bodies.

The scalp wound is cleansed and the wound excised by elliptical or other

incision, the surrounding parts being protected from contamination. The instruments used for this excision are discarded, the surgeon changes his gloves, and fresh towels are applied. With or without trephining, according to the circumstances of the case, all comminuted and depressed fragments of bone are removed or cut away with the nibbling forceps until adequate exposure of the dura mater is obtained. *If this membrane is not lacerated*, it should not be opened except under exceptional circumstances. Any incision of the membrane exposes the patient to the risk of infection of brain and meninges. It should only be opened when the patient is suffering from deep compression and when the membrane shows by its tenseness, want of pulsation and plum colour the presence of underlying blood-clot. In such cases, it is justifiable to open the dura mater, wash out the blood and sew up the membrane again.

*When the dura is lacerated*, with bone-fragments and foreign body within the brain, insomuch as they must be regarded as potential sources of infection, all must be removed whenever possible, each case being judged on its own merits and considered carefully from the radiographic and neurological points of view.

Bone-fragments superficially situated may be removed with forceps, whilst deeper bodies are localised with the finger, passed gently and judiciously along the track in the brain substance, and removed in the same way, or by means of suction. In the latter method a soft rubber catheter, attached to some simple suction apparatus, is passed along the track in the brain, and, by means of several introductions and withdrawals, blood-clot, broken-down brain substance and bone-fragments are withdrawn. This process should be continued till all foreign bodies possible are removed.

Considerable judgment is required as to fragments which are situated beyond easy removal. The process should be continued, therefore, until all fragments are removed, or until the surgeon is satisfied that he has taken away all such as can be removed without undue risk of incurring further damage.

Metallic foreign bodies may be removed in the same way, or with the aid of the magnet.

*Complications.*—Early complications are hernia cerebri, meningo-encephalitis, ventriculitis and osteo-myelitis of the skull. More remote ones are cerebral abscess, fits, both generalised and Jacksonian, paralyses of all sorts, chronic headache (cerebral œdema), neurasthenia, and insanity, delusional and homicidal.

*Prognosis.*—It is impossible to estimate the immediate mortality of gunshot wounds of the skull and brain. Statistics are based on the cases that survive and arrive at hospital. In such cases, all depends on the question of *dural penetration*. Perforating wounds present the highest mortality, approximating to 75 per cent. In penetrating wounds the mortality is about 50 per cent., and in those cases where the dura is not penetrated about 15 per cent.

**Injuries of the superior longitudinal sinus.**—It is necessary to add a few words about injuries of this sinus, many cases having occurred as the result of gunshot wounds of the vertex. Fragments of bone are driven into the sinus, producing thrombosis. The upper cerebral veins, passing upwards to their destination in the longitudinal sinus, become blocked secondarily. The cortex drained by these tributaries becomes swollen, soft and œdematous, with minute hæmorrhages into both grey and white matter. The resulting symptoms, the superior longitudinal syndrome, are, in the main, as follows :—

1. *Paralysis* of one or both lower extremities, the paralysis being most marked in the more distal segments, toes, ankle and leg.

2. Marked *rigidity* of the parts affected, with adduction and inversion of

the limb, so that the feet may cross one another when both extremities are affected.

3. *Exaggeration of reflexes*, with plus knee-jerks, ankle clonus and Babinski's sign.

4. *Loss of sense of position and of movements of toes and feet*, with little alteration in tactile sensation and sense of pain, heat and cold.

### Hæmorrhages within the Skull.

**Extradural hæmorrhage from the middle meningeal artery.**—The middle meningeal artery enters the middle fossa of the skull through the foramen spinosum. It soon divides into two main branches, anterior and posterior, both of which lie throughout between the dura and the bone, firmly attached to the membrane. Any hæmorrhage resulting from their injury will be confined to the extradural space unless the dura be also torn, in which case the blood will extravasate by preference into the subdural region. The anterior branch of the artery is the more liable to injury, as it lies in relation to, and grooves, the bones entering into the formation of the weak temporal region—weak because the diploic tissue is there absent and the bone proportionately brittle. The vessel is consequently very liable to be torn, more especially where it tunnels through the bone.

An uncomplicated middle meningeal hæmorrhage gives rise to a very definite train of symptoms, but, unfortunately, most cases are complicated by the presence of severe damage to the brain. In consequence, the more typical symptoms are liable to be obscured by those dependent on brain laceration and hæmorrhage into the subdural space—that is to say, by *concussion* and *compression*. The typical clinical symptoms detailed below are therefore not often seen in their entirety. Still, their general significance must be appreciated in order that the hæmorrhages, which are of common occurrence, may be recognised.

*Signs and symptoms.*—After the receipt of the injury, usually a blow on the side of the head with fracture of the skull, the patient is concussed, remaining unconscious for a variable period of time, minutes to hours. He then recovers sufficiently to give a fairly lucid account of himself, perhaps even to such an extent that he is enabled to walk to hospital or doctor. This is the "*lucid*" interval of a case of middle meningeal hæmorrhage. It is probably present in every case to a greater or lesser degree. Its importance, from a diagnostic point of view, cannot be overestimated. Then, if the patient is carefully watched, it will be observed that he becomes slow and uncertain both of speech and movement. This is the stage of *slow cerebration*, one of the first symptoms of beginning compression. He then becomes more dull, then unconscious, and finally comatose.

Coincident with this loss of senses, other symptoms may be observed pointing to general compression and localised brain pressure.

Amongst the symptoms pointing to *general compression*, in addition to the state of unconsciousness, the following should be noted:—(1) a slow, full pulse of high tension; (2) heavy and stertorous respiration, with puffing out of the cheeks on each expiration; (3) a cyanosed face; and (4) a rising temperature.

The *localised pressure effects* are quite definite—twitchings or convulsions, followed by paralysis of the contra-lateral face and upper extremity, the facial muscles being affected first and foremost. The lower extremity is seldom involved. These symptoms, both general and local, require some

explanation. The extravasation takes place between the dura and the bone, but the dura is firmly attached and some time must elapse before the extradural hæmorrhage attains sufficient dimensions to bring about general or local effects. Consequently, after the recovery of the patient from the primary state of concussion, there is a "lucid" interval, of variable duration, during which the hæmorrhage is gaining power. Then, when the clot is of sufficient size, general compression symptoms begin, the patient complaining of headache and suffering from "slow cerebration."

The localising symptoms—first twitchings and then paralysis of the contralateral face and upper extremity—are explained by the fact that the anterior

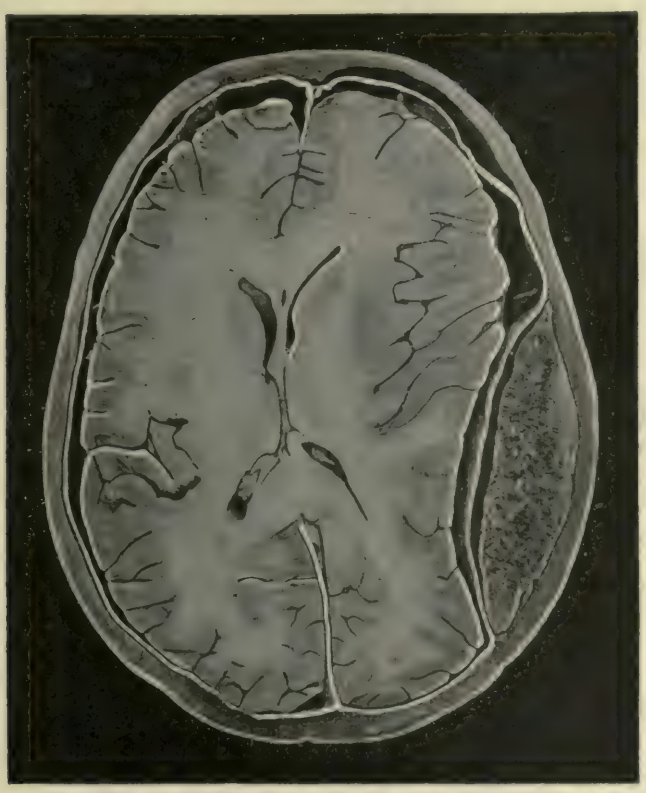


FIG. 149.—Middle meningeal hæmorrhage. Note the size and shape of the extradural extravasation and the compression of the brain. (St. Bartholomew's Hospital Museum.)

division of the middle meningeal artery, the one commonly injured, passes upwards towards the vertex of the skull in direct relation to the pre-Rolandic or motor area, the centres of which are arranged from above downwards for the movements of the opposite lower extremity, trunk, upper extremity and face, with the speech centres low down on the left side. The vessel is injured as a rule in the temporal region, low down so far as the motor centres are concerned. In consequence, the face centres suffer first, and, as the clot increases in size, the upper extremity comes next. The hæmorrhage, by reason of its pressure on the cortex, produces first irritation (twitchings) and finally paralysis.

The slowed pulse-rate, with high tension, and stertorous respiration of early compression, give place, later on, to *paralysis* of the centres, as is evidenced by increasing acceleration of the pulse, rapid fall in blood pressure, and the advent of Cheyne-Stokes respiration. The respiratory centre is the first of the vital centres to fail, the heart often beating for some minutes after breathing has stopped.

There are certain other symptoms to be noted in middle meningeal hæmorrhage, as follows :—

1. *Pupillary changes.*—It is stated that the pupil on the same side becomes fully dilated and irresponsive to light (the Hutchinson pupil). This is said to be due to direct pressure exercised on the third nerve, in the region of the cavernous sinus, the extradural hæmorrhage separating the dura mater from the base in such a way that the clot comes into direct contact with the nerve.

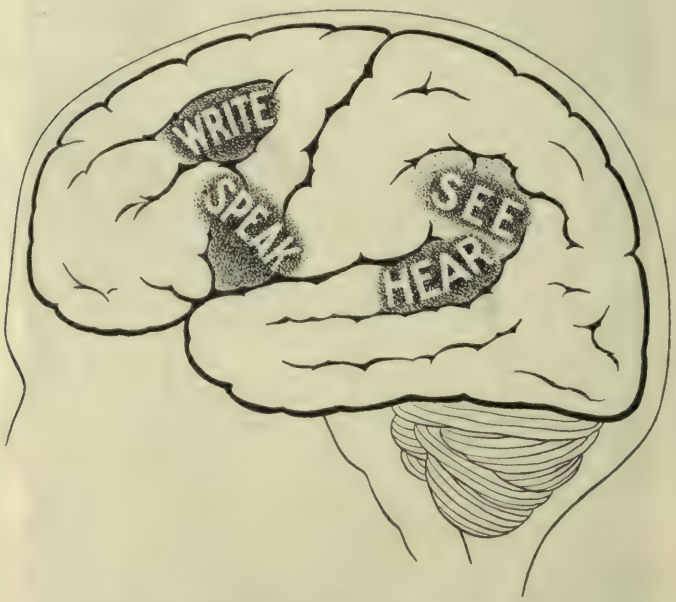



FIG. 150.—The four " speech " areas of the cortex.

This explanation is improbable, and the Hutchinson pupil itself is of infrequent occurrence. More commonly irregularities of pupil are observed, but with no marked consistency and of little diagnostic value.

2. *Temporal hæmatomata.*—As most cases of middle meningeal hæmorrhage are accompanied by a fracture of the bones entering into the formation of the temporal fossa, blood may escape from the extradural space through the fissures in the bone. In consequence, a hæmatoma may form in the temporal region, beneath and amongst the fibres of the temporal muscle, limited above by the attachments of the muscle and fascia to the temporal ridge and below by the zygoma. The swelling may be very tense, and ecchymosis appears on the surface within a few hours. When the communication between the extradural and temporal hæmorrhages is extensive the temporal hæmatoma may pulsate, and pressure applied to the hæmatoma may be so transmitted to the intracranial space as to produce twitchings or fits involving the contralateral face and upper extremity.

3. *Hæmorrhage from the ear.*—Profuse and long-continued hæmorrhage from the ear is very suggestive of an extradural hæmorrhage, the blood being forced into the middle ear through fissures in the tegmen tympani and so escaping externally through a ruptured membrana tympani.

*Treatment.*—The hæmorrhage must be controlled. A planned operation will not be necessary if there is a comminuted fracture in the temporal region. In the event, however, of there being no fracture or a mere fissure in the bone, a scalp flap is turned down allowing of the application of the trephine at a point which is 2 inches behind the external angular frontal process and the same distance above the zygoma. The disc is removed and the clot exposed. Fluid blood will escape. The gap is enlarged in the direction from which the blood appears to come, and the bleeding points exposed. If the torn artery is attached to the dura mater, a ligature is passed round the vessel on either side of the bleeding point. If the hæmorrhage comes from the vessel

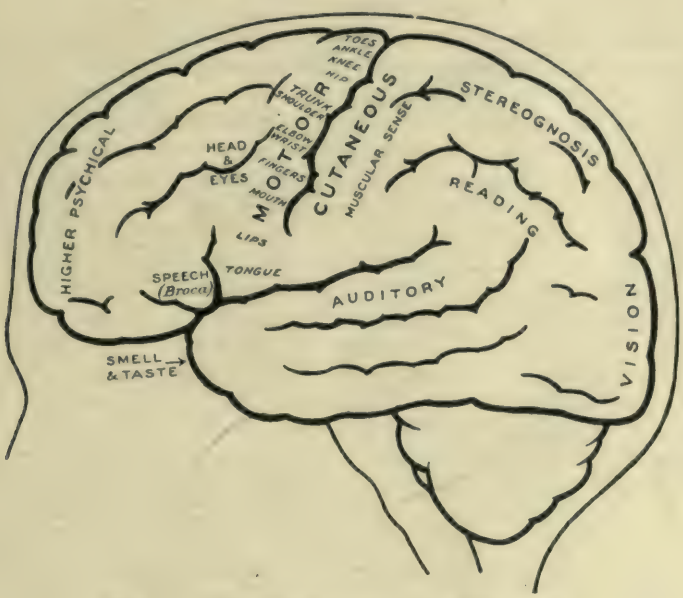



FIG. 151.—The cortical motor and sensory areas.

during its intraosseous course, the foramen may be plugged with sterilised wax, or a bone or wooden plug. A wooden match, sharpened and sterilised, may suffice. If the bleeding takes place from the vessel near its entry into the middle fossa through the foramen spinosum, the dura should be stripped away from the base and the foramen occluded with wax, or a wooden or ivory peg. The external carotid artery has been ligatured for this condition.

If the bone be extensively comminuted, it suffices to remove such portions of bone as will allow of adequate exposure of the clot and bleeding vessel.

After controlling the hæmorrhage the wound is closed without drainage.

The *prognosis* is good so long as the hæmorrhage can be controlled and provided that there is no serious injury to the brain.

**Subdural hæmorrhage.**—Hæmorrhage into the subdural space may be diffused or localised, the former condition being by far the more common. The blood is derived from two main sources, the cortical vessels in cases of brain laceration, and the venous sinuses of the brain. In both cases the blood tends

to become diffused widely throughout the subdural space, though invariably gravitating towards the basal region. There is one other source from which a subdural hæmorrhage may be derived, namely, from the middle meningeal artery. In this case, however, the arterial laceration must be accompanied by a corresponding tear in the dura mater. When such conditions are present the blood will escape into the subdural space in preference to stripping up the dura mater from the bone and forming an extradural hæmorrhage.

In some cases, for reasons not entirely understood, a subdural hæmorrhage remains localised to the region of brain injured, a considerable clot resulting. These localised clots—subdural hæmatoceles—are commonly related to the motor area of the brain, and in consequence definite localising symptoms are observed.

*The symptoms observed in diffused subdural hæmorrhages.*—In the most serious cases the patient never recovers from the initial profound stage of concussion. In the less serious, the concussion state rapidly gives place to that of active compression, the temperature steadily rising, the blood pressure increasing, and unconsciousness deepening till the patient shows all the signs and symptoms of deep compression.

Perhaps the most important symptom in the *diagnosis* of diffused subdural hæmorrhage is the fact that there is *no "lucid" interval* between the initial concussion and final concussion or compression stages. This results from the fact that the blood is rapidly diffused throughout the subdural space. In middle meningeal hæmorrhage some time is occupied by the stripping away of the dura mater from the bone. This fact alone should enable one to distinguish between subdural and extradural bleeding.

In any case *lumbar puncture* should be carried out, the presence of blood intimately mixed with the cerebro-spinal fluid confirming the diagnosis. In middle meningeal hæmorrhage, uncomplicated by brain injury, there is no free blood in the cerebro-spinal fluid.

*Treatment of diffused subdural hæmorrhage.*—When the patient remains obstinately in a state of concussion, treatment is carried out in accordance with the principles laid down on pp. 421 and 422. When the patient passes into the state of compression, decompression measures are adopted (see p. 421).

*The symptoms also observed in a localised subdural hæmorrhage* (*hæmatocele*). —Here there is the usual primary stage of concussion or cerebral shock. From this the patient recovers, but the recovery is incomplete, and later on he passes gradually into a condition of both local and general compression. At first sight these symptoms do not seem to differ markedly from those described under *Middle Meningeal Hæmorrhage* and *Diffused Subdural Extravasations*. In reality they are, so to speak, intermediate between the two. The brain is injured and the patient concussed. A clot forms derived from the torn cortical vessels, but the blood is venous in origin, its pressure is very low, and in consequence it remains *localised* in the region injured. For reasons not entirely understood, the clot appears to produce no marked pressure symptoms for the time being. The patient therefore recovers from his concussion but is not completely restored to health. He suffers from headache, is restless and irritable, has a poor appetite, and sleeps very badly. He is altogether changed in manner towards those with whom he comes into contact. This stage of incomplete recovery is known as the "*latent*" period. It endures for a variable period of time, seldom less than a week or more than three months. Then the picture changes. Either as the result of fresh bleeding

or by reason of changes taking place in the blood-clot, there are new developments, rather insidious in origin. The patient shows symptoms of increasing intracranial pressure, both general and localising. He becomes heavy and drowsy, the pulse-rate is slowed and the blood pressure rises. The temperature also shows periodic elevations. The more usual relation of the clot to the motor areas brings about definite localising symptoms—weakness or paralysis on the opposite side of the body, with exaggeration of reflexes. In some cases, the hemiplegic symptoms are so marked that the term "*traumatic late apoplexy*" has been applied to the condition.

When the clot is situated more over the mid-brain, sensory symptoms will be existent—numbness, formications, and an indefinite loss of sensation on the contra-lateral side.

If the significance of these symptoms be not recognised, the weakness progresses into actual paralysis and the drowsy mental condition into one of actual coma. General compression then holds the field, and, in many cases, death supervenes.

*Treatment of localised subdural hæmorrhages.*—As soon as the diagnosis is made, a scalp flap should be turned down and a disc of bone removed over the centre of the clot, the position of the hæmorrhage being located from the symptoms present. The diagnosis is confirmed by the tenseness and want of pulsation of the dura mater and by the plum colour imparted to the membrane by the underlying clot. The gap in the skull is enlarged according to requirements, the dura opened and the clot evacuated, mainly by means of gentle irrigation with hot saline solution. If the brain expands readily, no drainage is required, the dura being approximated and the scalp flap sewn up (for *Plating of the Skull*, see p. 440). If a cavity remains, the brain failing to respond at once to the relief in pressure, it may be advisable to drain for forty-eight hours.

The *prognosis* as to ultimate recovery is good.

At this point it will be advisable to summarise the main points in the *differential diagnosis* between the three varieties of intracranial hæmorrhage to which allusion has been made.

In all three there is a primary stage of concussion.

In *middle meningeal hæmorrhages* the patient recovers from the concussion, after which there is a definite "*lucid*" *interval*, perhaps of a few minutes' duration only, in other cases lasting several hours. During this period the patient is apparently sound, both mentally and physically. Compression symptoms, both local and general, then develop, progressing to the complete state of cerebral compression.

In *localised subdural hæmorrhages* the patient recovers from the concussion, after which there is a definite *latent period*, in duration from a few days to a few weeks. During this period the patient is not well. Compression symptoms, both local and general, then develop slowly, full compression finally holding the field.

In *diffused subdural hæmorrhages* the patient does not recover from the concussion stage. He either remains concussed and dies concussed, or the concussion stage passes, without any appreciable interval, into full compression.

There are some cases which do not follow the above-mentioned rules. They are usually such as combine two types of intracranial hæmorrhage, for instance, a middle meningeal hæmorrhage and a diffused subdural extravasation. In cases of such nature the clinical characteristics of the hæmorrhages become obscured.

### Septic Infections occurring in Head Injuries.

The various infections requiring consideration are as follows :—meningitis or meningo-encephalitis, cerebral abscess, hernia cerebri, and thrombosis of the venous sinuses of the brain.

**Meningitis** or **meningo-encephalitis,** though liable to develop in any compound fracture of the skull, vault or base, occurs most frequently in gunshot wounds of the skull and brain. In such wounds, the scalp wound being necessarily infected and every bone-fragment driven through the dura into the brain being a potential source of infection, it stands to reason that unless

Fig. 152.—A case of hernia cerebri, resulting after the evacuation of a traumatic abscess of the frontal lobe.

prompt measures are adopted the infective process may readily spread to the meninges and brain, giving rise to meningitis or meningo-encephalitis.

**Abscess of the brain.**—Abscesses also arise most frequently after gunshot wounds, suppuration developing around any foreign body or bone-fragment driven through the dura into the brain substance. As a general rule there is but slight attempt at localisation of the infective process, and in consequence the surrounding brain soon becomes infected, leading to a condition of diffuse spreading encephalitis. The ventricles may be involved, and pus spreads rapidly to the spinal canal.

**Hernia cerebri** invariably depends upon diffuse brain infection, and is often associated with the presence of a foreign body or fragments of bone which have been driven through the dura mater into the brain substance. The resulting infection and œdema lead to such swelling of the brain that some of the latter forces its way through the rent in the dura and the gap in the osseous walls, presenting on the surface as a soft pulsating mass. The

hernia may be quite small, or the protrusion may increase in size rapidly until a mass is extruded the size of a cocoanut. It varies also in size according to any alteration in intracranial pressure, increasing when the patient coughs or strains, diminishing when the head and shoulders are raised in bed.

According to the size of the rent in the dura mater, the hernia possesses a wide or narrow connexion with the main intracranial mass. When the dural opening is very small, the neck is much constricted, and the hernia is soft, sloughy, and bathed in pus (fungus cerebri). The pus, welling up around the neck of the hernia, may be associated with a subdural or cerebral collection. Under such conditions, unless the membranes become sealed off around the neck by adhesions, there is grave risk of a spreading meningo-encephalitis.

A distinction should be made between a *hernia* of this nature and a *hernial protrusion* which is deliberately induced by the surgeon with the object of producing a decompression effect—for example, a subtemporal decompression. In such hernial protrusions the brain, protruding through the incised dura and through the aperture made in the skull-wall, is not infected and covered with healthy scalp.

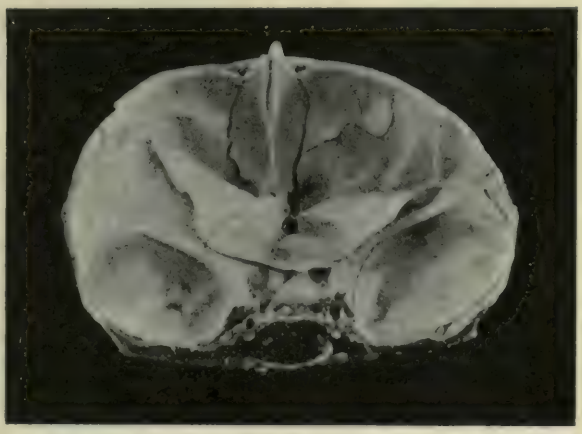


FIG. 153.—A fracture of the anterior fossa. The fracture extends into the cribriform plate, and the overlying dura was torn. The patient died of meningitis.

**Thrombosis of the venous sinuses.**—The superior longitudinal sinus, the lateral and cavernous sinuses may all become thrombosed as the result of injury. In the event of a compound fracture of the skull in the immediate neighbourhood of the superior longitudinal and lateral sinuses, fragments of bone may be driven into the sinus, producing thrombosis. Such thromboses are of more likely occurrence in the presence of an infected surface wound.

Thrombosis of the superior longitudinal venous sinus is alluded to further in *Gunshot Wounds of the Skull* (see p. 425).

**Meningitis.**—The *symptoms* of meningeal infection usually develop suddenly, though, for a short time before, suspicion may have been aroused as to the occurrence of some change in the patient's general condition. The first real indication of the onset is a rigor, often of an intense character. Then comes headache, very severe and with exacerbations. The patient becomes restless, irritable, tossing about in bed, almost incapable of control, and delirious. These symptoms usher in the *period of excitement*, this being followed by that of *depression*.

In the *period of excitement*, in addition to the state of mental excitement, the following symptoms are observed:—The temperature is continuously high, the pulse full—of high tension—bounding and increased in rate. The skin is burning, the face flushed. Special symptoms arise according to

whether the cortex or base of the brain is mainly affected. Twitchings and general convulsions point to cortical irritation; painful cramps and contractures are also seen. When the base of the brain is involved the cranial nerves are affected as follows:—

*Optic nerve.*—Papillœdema, seen, however, only in the later stages.

*Third, fourth, and sixth nerves.*—Squints and alterations in pupillary action.

*Fifth nerve.*—Trismus, or spasmodic contraction of the jaw.

*Seventh nerve.*—Facial paralysis.

*Eighth nerve.*—Deafness.

*Ninth, tenth, and twelfth nerves.*—Difficulty in breathing and swallowing.

*Eleventh nerve.*—Rigidity of the neck and torticollis.

*Upper cervical nerves.*—Retraction of the head and neck, stiffness of the neck muscles.

In addition, photophobia, tâche cérébrale, exaggerated reflexes, flushings and sweats point to the excited condition or lowered resistance of the brain cells.

*The period of depression.*—The centres becoming exhausted, stupor and coma displace the previous existent state of mental excitation. The temperature remains high and the approaching paralysis of the cardiac, vaso-motor, and respiratory centres is shown by the increasing rapidity of the pulse, a general fall in blood pressure and Cheyne-Stokes respiration. The whole duration of the disease is seldom more than three or four days.

Confirmatory evidence as to the presence of meningitis may be obtained by *lumbar puncture*, fluid being withdrawn which is at high pressure, turbid and containing many polymorpho-nuclear leucocytes and organisms, the exact nature of which should be verified at the earliest possible opportunity.

*Treatment.*—In the earlier stages of meningitis it is absolutely essential that *free drainage* should be supplied in the region of the primary infection. The scalp and bone are explored with that main object in view. Such operative measures should be carried out in conjunction with lumbar puncture, repeated as often as seems desirable. Suitable vaccines are administered; urotropin may be given in 15 and 20-grain doses—with the object of minimising the infection through the excretion of the drug in the cerebro-spinal fluid—and morphia administered in order to quiet the patient.

In the later stages little can be done. In spite of all measures the prognosis is eminently unfavourable.

**Absecss of the brain and hernia cerebri** (see also Section IX.).—Most traumatic abscesses of the brain are acute and situated on the surface of the cortex in close relation to the site of osseous injury. They are frequently associated with meningeal infection, so much so that they partake more of the nature of a meningo-cortical abscess than a brain abscess proper. The more chronic abscesses are situated immediately beneath the cortex, developing in the white matter. Such abscesses are usually dependent on infection from the middle ear, frontal sinus and ethmoidal cells, though occasionally they do arise in connexion with a chronic suppurating scalp wound. Brain abscesses may also develop in relation to endocarditis, gangrene of the lung, etc., and are in reality part of a general pyæmic process. There may be more than one suppurating focus in the brain at the same time.

*Acute traumatic abscess.*—The abscess is usually related to an infected compound tracture of the vault, and may surround some foreign body, bullet, fragments of bone, cloth or hair. The boundaries of the abscess are but ill defined, and there is considerable infection of the surrounding brain matter,

with softening, hæmorrhages, etc. The abscess is rather indefinite in its development. The patient may be showing evidence of recovery from the original injury, when, on or about the third day, his condition undergoes a change for the worse. This change is ushered in by a rigor, after which the temperature remains high, with periodical exacerbations. Headache, restlessness, and delirium are present. Vomiting is a marked feature. It may be almost incessant, and the patient emaciates rapidly. The pulse is increased in rate, and is full and bounding. Localising features may be present if the abscess is related to the cortical motor areas, fits on the opposite side of the body, or general convulsions.

The scalp wound is found to be infected and bare bone may be felt.

The *symptoms* in general are very similar to those described under *Menin-*

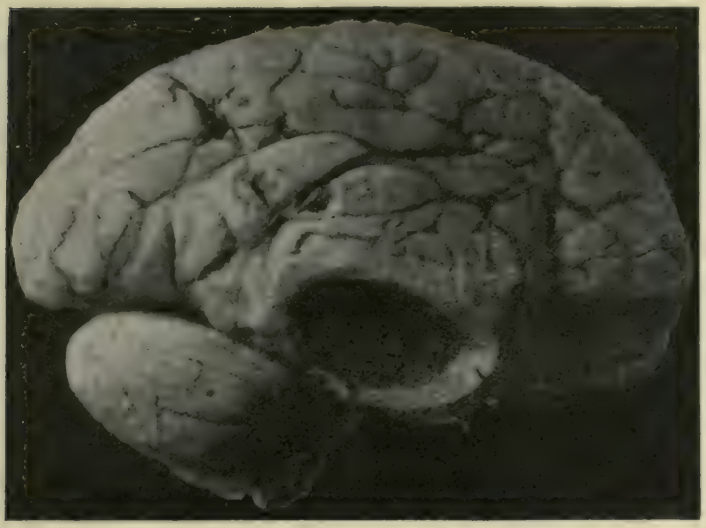


FIG. 154.—Abscess of the temporo-sphenoidal lobe. (St. Bartholomew's Hospital Museum.)

*gitis*, the period of excitation giving place to that of depression, with gradual failure in cardiac, vaso-motor, and respiratory centres.

In *chronic abscess of the brain* the symptoms are more definite. The patient has recovered from the initial injury, has perhaps been well for some time, when it is observed that he readily becomes irritated, appears to lose interest in his work, complains of a more or less incessant headache, sleeps badly, and suffers from a complete loss of appetite, losing nutrition accordingly. This is the *initial* stage of the abscess formation.

In the *manifest* stage the three cardinal symptoms of brain abscess develop —headache, vomiting, and optic neuritis. The *headache* is very severe, incapacitating the sufferer from all interest in life. It may be localised to the region of the abscess. *Vomiting* is of the so-called "cerebral" type, having no relation to the ingestion of food and preceded by no nausea or retching. *Papillœdema* develops, and is usually more marked on the side of the lesion, though not necessarily so. In any case it soon becomes bilateral unless the abscess is diagnosed and evacuated, in which case it rapidly gets less. If allowed to progress, post-neuritic atrophy is soon observed.

The pulse-rate and temperature are said to be lowered. This is hardly correct. The temperature is usually continuously above normal, one or two degrees, with some further increase towards the evening. These temperature changes result from the fact that the patient is continuously absorbing toxins from the cavity of the abscess, and perhaps also from a suppurating scalp wound with necrotic bone. The pulse-rate, however, is not increased in proportion. In other words, there is definite disproportion between the temperature and pulse-rate. Thus, the temperature may be 101° F. and the pulse-rate 80. This *relative slowing of pulse* is most important, almost patho-gnomonic of the condition.

The general mental condition of the patient varies in proportion to the size and situation of the abscess. Thus, a small cerebellar abscess in the limited space of the subtentorial chamber will bring about more marked stupor than when a larger abscess is situated in the supratentorial region. The state of *slow cerebration* changes into stupor, and stupor into coma. It may also be added that an abscess in the frontal lobe not infrequently leads to a curious mental state of suspicion and moral perversion, the patient being dirty in his habits though well aware of his misdeeds.

*Localising* features may also be present when the abscess is related to the motor cortex, not necessarily only when situated in that part of the brain, but also in its immediate neighbourhood. Thus, a *temporo-sphenoidal* abscess may cause paralysis of the opposite face (and aphasia if the lesion is on the left side) from upward pressure on the lower cortical motor areas, and a *frontal* abscess may lead to contra-lateral weakness or paralysis by backward pressure exerted on the corona radiata evolving from the Rolandic area.

In all cases of suspected abscess of the brain repeated *leucocyte counts* should be made. There are but few cases of brain abscess in which there is not a definite and increasing leucocytosis.

*Treatment.*—In the treatment of the more *acute brain abscesses*, such as are associated with a compound fracture of the vault, and often with foreign bodies in the brain substance, the aperture in the bone is enlarged, and depressed fragments removed until healthy dura mater is seen on all sides. If pus is seen coming through the rent in the dura, the opening is enlarged and free drainage established. Search is also made for any foreign bodies which have been localised previously by X-rays. If they can be removed and the abscess efficiently drained, there is some hope of recovery.

The condition may be complicated by the presence of a *hernia of the brain.* In the treatment of this condition the first essential is to drain any abscess associated therewith and to remove any foreign bodies. Subsequently the treatment consists of keeping the hernia as clean and dry as possible, of sitting the patient up in bed so as to reduce the intracranial pressure, and of repeated lumbar punctures. In the absence of severe sepsis, even if the hernia is of considerable size, the protrusion may gradually recede and heal over. If the hernia is shaved off, as is sometimes recommended, it usually re-forms, and there is associated with this form of treatment a special danger of opening up the ventricles, for the protruding brain often drags out with it one of the horns of the lateral ventricle.

The more *chronic abscesses* are usually situated in close relation to the source of infection—a suppurating frontal sinus or mastoid antrum. The primary source must be treated and the abscess drained.

A *chronic abscess*, being situated as a general rule in immediate relation to the source of infection, is exposed by trephining or by the enlargement of an already existent gap in the skull. The dura is opened, the abscess evacuated

by trocar and cannula and the cavity drained for a few days. Premature removal of the drainage tube tends to allow of the reaccumulation of pus and the spread of the infection to neighbouring parts of the brain.

**Cavernous sinus thrombosis.**—The cavernous sinus has many connexions, communicating with its fellow of the opposite side, with the facial and orbital region in front, the base of the skull and pharyngeal region below, and with the petrous bones and petrosal sinuses behind. In consequence, many acute and chronic infections of the regions drained by the sinus may lead to cavernous sinus thrombosis, the thrombus being commonly of the infective type.

The *localising symptoms* are due to the presence of the thrombus and its extension to connecting venous channels. Proptosis develops early and progresses rapidly, associated with ocular palsies, disturbances of vision, and œdema of the lids and conjunctiva. The thrombus may extend to the opposite sinus, in which case the proptosis and other symptoms become bilateral.

The more *general symptoms* result from toxic absorption and the transference of infected portions of the thrombus to other parts of the body. High temperature, frequent rigors, and a high pulse-rate are observed, also enlargement of the spleen, pulmonary symptoms, etc., according to the site of lodgment of the infected particles.

*Treatment.*—Little can be done for this condition. Attempts have been made to expose and drain the sinus, but the results obtained by operation are by no means encouraging.

## The Remote Effects of Head Injuries.

It has been estimated that of every 100 cases that recover from a serious head injury 39 per cent. are capable of returning to full work, 46 per cent. are able to do light work, and 15 per cent. are totally incapacitated. It is probable, however, that the estimate of 15 per cent. total incapacity is too low; 25 per cent. would be nearer the mark. On investigating the causes leading to partial or complete inability to work, the more frequent are headaches, dizziness, deafness, and ocular troubles. Others are paralyses, fits (both focal and general), traumatic neurasthenia, and insanity.

It does not require any very extensive operative experience of these varied conditions to show that they are dependent, in the great majority of cases, on definite changes in the bone, membranes or brain. Pathological conditions of the bone include all degrees of depression, either of the whole thickness of the skull or of the internal table alone, the lodgment of small portions of bone in the cortical substance, and thickening of the bone in the region at which the blow was applied. Changes in the membranes are numerous and varied—adhesions between the scalp and the membranes when there is some osseous deficiency, matting together of the dura, arachnoid and pia, glueing of the membranes to the brain, and cysts in relation to the membranes. These *cysts* are of two main types—*cysts derived from blood-clot* and *cysts of new formation*. In the former case the walls are formed partly by matting of the membranes and partly by a fibrinous exudate. The contained fluid is of a brownish colour, with the deposition of hæmatoidin crystals in the wall of the cyst. The cysts of new formation, often termed *arachnoid cysts*, are probably cysts "*ex vacuo*"—that is to say, there has been some loss or shrinking of the brain substance, leaving a space which becomes filled with cerebro-spinal or serous fluid. In some cases perhaps these arachnoid cysts are actually of new formation, due to some chronic inflammatory process in the membranes themselves. In either case, the walls are quite thin and the contained fluid

clear. The brain changes include actual loss of substance, compression from the pressure exercised by bone, cyst, etc., degeneration of the tracts leading from the cortical regions affected, and œdema. This state of *œdema* requires further explanation, as it is of almost constant occurrence as a remote effect of head injury. Its existence is characterised by the presence of fluid in the subdural space (where there should be no fluid under normal conditions), excess of fluid in the meshes of the pia-arachnoid, and a boggy or waterlogged state of the brain itself. It is a vascular phenomenon and explained by the following hypothesis. The cerebro-spinal fluid is an active secretion and is, so to speak, sucked up by the cerebral veins in direct proportion to the rate at which it is formed, the cerebro-spinal tension and venous pressure being almost equal. Then, as a consequence of the injury, there is such disturbance of cerebral circulation as to result in general venous congestion and some increase of venous pressure. The cerebro-spinal fluid, therefore, is absorbed less readily, and there may even be some transudation of serum from the veins into the surrounding tissues. In consequence, there is excess of fluid throughout the cavity of the skull.

In general, therefore, it would appear that *definite pathological changes are to be found in almost every case exhibiting the remote effects of head injuries.* From this statement two facts may be deduced—(1) that prompt operative treatment, *e.g.*, the evacuation of a blood-clot, would remove the exciting cause at an early date and so tend to prevent the advent of œdema, etc. ; and (2) that operative treatment may greatly improve the condition of the patient even when the remote effects have already declared themselves.

**Traumatic neurasthenia.**—This is a curious condition in which the patient evidences general mental deterioration. He is irritable, readily excited, depressed, changed in his relations to those near and dear to him. In habits he is dirty and perhaps immoral. He suffers greatly from insomnia, loss of appetite, and complains of a more or less constant headache. From a strictly localising point of view these symptoms are very indefinite. From the clinical point of view they are quite definite.

The *treatment* is proportionately difficult. Rest, both mental and physical, is absolutely essential. A definite "rest cure" is often indicated. In some cases a subtemporal decompression, carried out with the object of assisting the cerebral circulation by draining away superfluous fluid, may be indicated and carried out with beneficial results.

**Traumatic insanity.**—An acute maniacal condition may arise within a few hours of the injury, almost certainly dependent on acute cerebral œdema. Various degrees of insanity also may develop as a remote effect of the lesion. The prognosis is bad, but some brilliant results have been obtained by operation, cysts and similar pathological conditions being found and remedied.

**Traumatic cephalalgia.**—Headache is the most common of all the after-effects of head injury, sometimes localised to the region at which the injury was received, at others more general in character. It is more or less constant, always exaggerated by exertion, mental and physical, indulgence in alcohol, exposure to the sun, etc. When localised to a certain definite region it is likely to be dependent on a local exciting cause—blood-clot, cyst, etc.—and operative treatment may bring about considerable benefit. When diffused in character, after the failure of ordinary remedies, a subtemporal decompression may lead to a satisfactory result.

**Traumatic epilepsy.**—Epileptic fits may be either Jacksonian in character or generalised. A *Jacksonian fit* should present the following features :—

1. The fit should be preceded by some sensory or motor aura, this varying according to the region primarily involved.

2. The fit should commence by twitchings of the parts supplied by the motor area which is directly related to, or in closest proximity to, the site of the lesion.

3. The fit either remains localised to the part primarily involved, or, as is usually the case, it should spread to neighbouring cortical areas in regular order—that is to say, according to the arrangement of the cortical motor areas. Thus, if a fit starts in the right face, it should then involve the right upper extremity and then the lower extremity. If it spreads to the opposite side, the first centres involved are those responsible for the movements of the left lower extremity.

4. In the early stages of the fits the patient should retain consciousness during the attack, and there should be no after-results in the way of headache or paralysis. After the attacks have lasted for some months or years it will be seen that consciousness is lost during the attacks, that the patient suffers from considerable malaise after the fit, and that the parts primarily involved may be definitely weakened, perhaps paralysed.

In many cases the fit appears to be generalised from the first, the patient losing consciousness immediately on its development, throwing the limbs about in a purposeless manner, frothing at the mouth, biting the tongue and exhibiting in many respects the typical characteristics of ordinary epilepsy. Even in these cases, however, careful observation will show that the fits commence in reality in some definite region. It can be demonstrated, in most cases, that the fits are of such a nature as to fulfil the main requirements of a Jacksonian epileptic attack.

*Treatment of epilepsy.*—From a causative point of view, sufficient evidence has been brought forward to show that a large percentage of cases of traumatic epilepsy are dependent on some local exciting cause, depression of bone, cysts of the membranes, cerebral œdema, etc. Some of these conditions may be cured, others may be relieved. Again, if an expectant attitude be adopted, many cases end their days in a lunatic asylum. On these grounds operative interference ought to be carried out in suitable cases, more especially in the presence of typical Jacksonian epilepsy and in the existence of obvious osseous defect. It has been argued that the results obtained by operation are not sufficiently satisfactory. Absolute cures are certainly few in number, but in the majority of cases amelioration will be brought about both in the number in fits and in their intensity. This is in itself sufficient justification for the urgent consideration of operative interference. In a properly-conducted operation the risks may be disregarded.

The *operation* is necessarily rather of the nature of an exploration. Whether there be an osseous deficiency or not, a scalp flap is framed, suited to the region, but of considerable size. Plenty of room is required for the successful carrying out of the operation. If trephining is necessary, the trephine is applied to the bone immediately over the regions suspected. Depressed bone is cut away in such a way as to allow of proper inspection of the underlying regions. The bone being removed, the dura is exposed. In practically all cases the *membrane must be incised and the underlying parts inspected.* A cyst is evacuated, a blood-clot washed out and drained; depressed bone is cut away or elevated.

When both by clinical reasoning, according to the symptoms, and by the condition of the cortex as found after exploration, it is seen that a certain cortical area is diseased, it has been suggested that *excision of the particular cortical area* may be beneficial. This course is not to be commended, for, although there may be some immediate benefit from the operation, the

ultimate results are unsatisfactory. The excision merely leads, in the future, to greater cortical scarring and further tract degeneration.

*The bone removed should not be replaced.* It is certain that small fragments of bone, when reintroduced, are absorbed, merely acting as a scaffold for the formation of fibrous tissue. Furthermore, in the event of an infected wound, suppuration will continue till the fragments of bone have been removed.

To *protect any gap in the skull*, and at the same time to *prevent the formation of adhesions between the scalp and the membranes or brain*, two courses are available—(1) the formation of a bone flap from the neighbouring part of the skull (König-Müller method), and (2) the interposition of a silver plate between the scalp and the bone. The latter method is to be preferred. After the completion of the main operation, or at a later stage, a thin silver plate, moulded to the required shape, is placed over the gap, between the scalp and the bone, not anchored in position by screws, but merely resting on the base of the scalp flap. Later on it is further maintained in position by the scar tissue forming along the line of the scalp incision. For this method of treatment asepsis is absolutely essential. The mildest form of suppuration renders the removal of the plate necessary. These plates cause no special irritation, and they may remain *in situ* indefinitely.

When there is insufficient dura to cover the cortex of the brain, additional material may be obtained by excising a portion of fascia—temporal fascia, ilio-tibial band, etc.—and utilising it in such a manner as to fill in the gap, stitched to the dural margins where necessary.

The *results* obtained by operative interference are not unsatisfactory. Some few cases are permanently cured, and many are alleviated, both in regard to the frequency and intensity of the fits.

An apparent improvement in the condition of the patient after operation is the rule, but many months must elapse before it can be accepted as an actual improvement. Considerable patience is required, and during the period of probation the patient should be treated with small doses of bromide, should receive all possible moral encouragement, combined with *rest*, mental and physical.

**Traumatic post-orbital aneurysm** (see also Section V.).—A late effect of head injury, of a different type to those previously mentioned, is traumatic post-orbital aneurysm. It occurs in the following manner:—A fracture of the anterior or middle fossa of the skull may so lacerate the internal carotid artery and the cavernous sinus that a fistulous communication exists between the two vessels, some arterial blood at high pressure being pumped at each systole into the venous channel (arterio-venous aneurysm).

The *symptoms* resulting from such a communication are—(1) those of the aneurysm itself, and (2) those resulting from the pressure exercised on surrounding soft parts.

*Aneurysmal symptoms.*—A tumour is seen at the upper and inner angle of the orbit, producing a downward and outward protrusion of the globe (proptosis). The swelling pulsates, and, on compression of the common carotid of the same side, the swelling decreases in size and the pulsation virtually ceases. On removing the compression the tumour rapidly fills up again, and for a short time pulsates more forcibly than before. On gentle examination a thrill will be imparted to the fingers, and on auscultation a well-marked hum will be heard, the bruit being conducted some distance over the surface of the skull, more especially in the direction of the venous sinuses. Of these noises the patient is painfully conscious, especially when lowering the head or during exertion. They are compared by him to the whirring of wheels, the buzzing of bees, etc

*Pressure symptoms.*—The pressure exercised on the cavernous sinus leads to the engorgement of all its afferent vessels. There is œdema of the lids of the conjunctiva and dilatation of palpebral, conjunctival, scleral, and retinal veins. The cornea itself may slough as the result of interference with its nutrition. The ocular nerves are compressed, with neuralgia along the distribution of the sensory branches, and with squints and pupillary alterations as the results of the pressure on the motor divisions.

All these symptoms tend to develop progressively, with serious damage to the eye and optic nerve. In the event of the tissues sloughing, frequent hæmorrhages may take place, and there is always the risk of infection, both of the more superficial tissues and of the cavernous sinus.

*Treatment.*—Under complete rest the progress may be arrested, though such a favourable result is highly problematical. The application of a constant pressure to the common carotid, either instrumental or digital, in the anticipation of producing thrombosis in the region of the aneurysm, is contra-indicated. This method is painful, tedious, and usually quite useless. If the proptosis diminishes markedly on the application of digital pressure to the common carotid artery, either that vessel or the internal carotid should be ligatured. Ligature of the main vessel might interfere seriously with the cerebral circulation if carried out soon after the accident. Such a result, however, is very unlikely to occur if the patient is prepared by being kept at rest for some weeks. Ligature of the internal carotid presents the disadvantage that it does not always bring about the desired result. There is such free anastomosis between the angular and other branches of the external carotid with branches of the internal carotid that but little benefit may be obtained.

In most of the reported cases the ligature was applied to the common carotid. The results obtained by such treatment are satisfactory. The proptosis at once diminishes, the deformity becomes far less conspicuous, and the noises in the head cease. In any case, however, it is highly probable that vision will be lost in the affected eye, from the stretching of the optic nerve and thrombosis of the retinal veins.

## Tumours of the Brain.

Tumours may arise in any part of the brain, and though they are more commonly situated in the cerebrum than in the cerebellum, yet, in proportion to the size of the two parts, they are relatively more frequent in the latter situation. Many varieties of tumour formation may be seen, the more ordinary types being *gliomata* and *sarcomata*, also fibromata and endotheliomata, arising from the membranes or from the sheath of the eighth nerve. Both gummatous and tuberculous disease of the brain are of comparatively infrequent occurrence. *Carcinoma* never arises as a primary tumour, though secondary growths, often multiple, may be observed in the late stages of mammary and other glandular varieties of carcinoma. Similar remarks apply to *melanotic sarcoma*.

These tumours vary considerably in their rate of growth and tendency to spread. Thus, sarcomata and gliomata, though possibly removable in their earliest stages, soon invade the surrounding tissues and become inoperable. On the other hand, fibromata, endotheliomata, and some syphilomata remain quite localised, and may be easily removed when situated in a surgically accessible position. Tuberculomata are less favourable; they are often multiple, and are sometimes associated with a tuberculous infection of the meninges.

*Pituitary* tumours present many special symptoms and are dealt with separately.

The *symptoms* observed in tumour formation should be discussed under two headings :—

1. *General symptoms*, dependent upon the general increase of intracranial pressure.

2. *Localising symptoms*, dependent upon the position of the tumour in its relation to the areas of the brain.

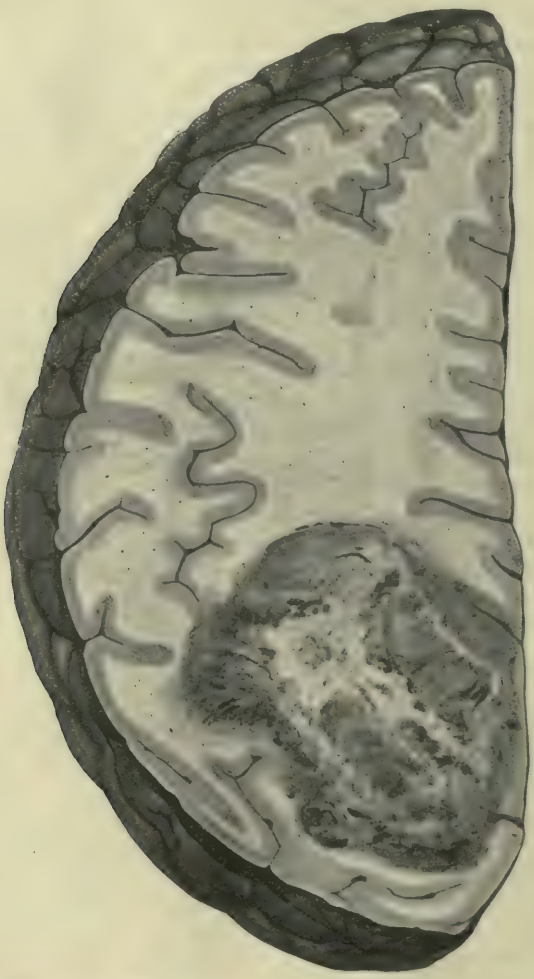


FIG. 155.—An infiltrating glioma of the brain. (St. Bartholomew's Hospital Museum.)

**General symptoms.**

*Headache.*
*Mental disturbances.*
*Papillœdema.*
*Vomiting.*
*Alterations in pulse, blood pressure, respiration and temperature.*

**Headache.**—A very constant symptom. It is usually very severe, with periodic exacerbations, and but little amenable to therapeutic measures. It

may be localised to the region of the tumour, but there are so many exceptions that no special value can be attached to this symptom alone unless the headache is accompanied by localised pain on palpation and percussion of the skull.

**Mental disturbances.**—The patient is apathetic or irritable in the early stages of tumour development, unable to concentrate his attention, often exhibiting a typical state of "slow cerebration" (see pp. 426 and 436), forgetful, and frequently immoral in habits. Later on he becomes more dull-witted, heavy, stuporose, and finally comatose.

**Papillœdema.**—A valuable symptom in tumour formation, though not universally present. It is due to the effect of pressure, damming up of fluid

Fig. 156.—A fibroma of the dura mater, indenting but not invading the underlying cortex. (St. Bartholomew's Hospital Museum.)

within the vaginal sheath of the optic nerve, with consequent œdema, compression of the lamina cribrosa, and interference with the circulation. The degree of papillœdema is fairly accurately measured by the amount of swelling of the disc.

Though papillœdema is usually bilateral, it is stated that it commences on the side of the lesion and, when bilateral, that it is more intense on the side of the tumour. Unless the intracranial pressure can be relieved, either by the removal of the tumour or by decompression, the œdema inevitably ends in optic atrophy and complete blindness.

The size of the tumour probably exercises little influence on the degree of

papillœdema. The position of the tumour is far more important. Thus, it is most common when the tumour is situated in the cerebellar region and in the temporo-sphenoidal lobes and least common in post-central tumours.

**Vomiting** is of the so-called "cerebral" type, having no special relation to food and unassociated with nausea. It takes place every other day or so, perhaps two or three times in the twenty-four hours, generally in the morning and often after alterations in posture. It is probably dependent on stimulation, by the increasing pressure, of the medullary vomiting centre. As a result of this vomiting and a general distaste for food, the patient emaciates rapidly.

**Alterations in pulse, blood pressure, respiration and temperature.**—In the earlier stages there is little change, beyond slight rises of tempera-

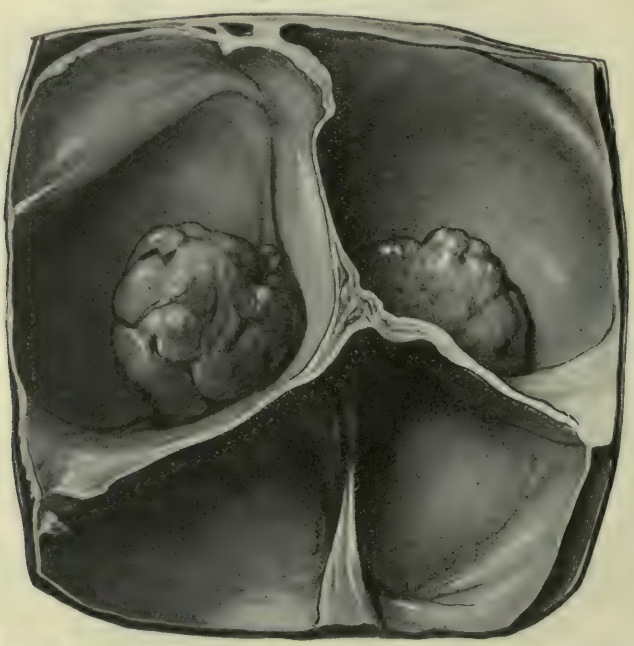


Fig. 157.—Symmetrical tuberculous tumours lying above the tentorium cerebelli and separated from one another by the falx cerebri. (St. Bartholomew's Hospital Museum.)

ture and some acceleration of the pulse towards the evening. In the fully-developed stage the pulse is slowed, of full volume and high tension; respiration is heavy and somewhat irregular in rhythm, and the temperature is subnormal. In the terminal stages, owing to the approaching exhaustion of the medullary centres, the patient becomes cyanosed and the pulse small and rapid, the blood pressure falls, and respiration becomes Cheyne-Stokes in character. The temperature usually rises to 104° F. or more, though occasionally, owing to the complete breakdown in the process of heat production, it may be so low that it can barely be registered, even in the rectum. Death results primarily from respiratory failure.

**Localising symptoms.**—These vary according to the position of the tumour. In the *anterior frontal* region, one of the so-called "silent" areas of the brain, there are no marked localising features beyond loss of smell (anosmia),

with secondary impairment of taste, and certain rather indefinite mental changes. The frontal lobes are regarded as exercising control over the higher faculties of man. In disease the patient may lose these qualities, becoming immoral, dirty, and generally perverted. He may also evince a curious air of suspicion, with respect to questions asked, etc. In some cases a state of mental elation or exhilaration has been observed.

In the *pre-central or motor area* localising features are definite. Usually there are fits, often typically Jacksonian (see p. 438), involving the opposite side of the body, with weakness or even paralysis of the opposite face and extremities. Muscular weakness is accompanied by exaggerated knee-jerks and well-marked extensor-plantar response (Babinski's sign). The paralysis is likely to be of the spastic type, with greatly increased reflexes, and perhaps with later contractures of the limbs. If the tumour be situated on the left side, motor aphasia may be present.

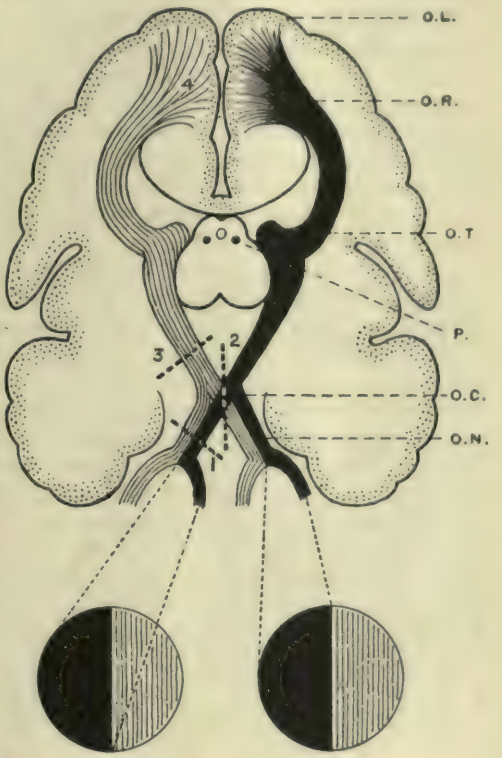



FIG. 158.—Diagram to illustrate the visual paths. O.L., the occipital lobe. O.R., the optic radiation. O.T., the optic tracts. P., pupillary fibres from the optic tracts to the third nerve nucleus. O.C., optic chiasma. O.N., optic nerve. 1. Blindness of the affected eye. 2. Bitemporal hemianopia. 3. Bilateral homonymous hemianopia, with hemianopic pupillary reaction. 4. Bilateral homonymous hemianopia, pupillary reaction normal.

In the *post-central or sensory area* the tumour is liable to exert considerable pressure effect in the forward direction, and in consequence epileptic attacks are of frequent occurrence. These attacks, however, ought to be preceded by sensory auræ, both these and the motor phenomena varying according to the situation of the tumour with reference to the cortical areas involved. The fits also may be succeeded by alterations in sensation—tinglings, numbness, etc., in the parts primarily involved or compressed. When the tumour includes the *marginal* and *angular* convolutions, word-blindness may be present. When the tumour extends more deeply into the brain substance, the visual fibres passing forwards from the occipital lobes, the optic radiation, may be compressed, with consequent diminution or loss of vision in the temporal half of the retina on the same side and in the nasal half on the opposite side (homonymous hemianopia). Similar visual changes may be observed when the tumour occupies the *occipital* lobe.

In the *subtentorial region* the more prominent symptoms are vertigo, the patient tending to fall towards the side of the lesion, ataxia, and inco-ordina

tion of movement. Nystagmus also is usually present, coarse lateral movements being the more common.

In that *extracerebellar* neoplasm known as the *acoustic* tumour—a fibroma arising from the sheath of the eighth nerve in close relation to the internal auditory meatus—the patient is stone-deaf on the affected side, perhaps on both sides, as these tumours show a disposition to be bilateral. In addition, there may be paralysis of the corresponding facial nerve and neuralgic pains or actual anæsthesia from pressure exercised on the neighbouring fifth nerve.

When the tumour is *intracerebellar*, and laterally situated, paresis with exaggerated reflexes, or even paralysis of the spastic type, will be seen on the same side as the tumour. If, however, the tumour approaches to the middle line or invades the opposite side, the extremities on both sides may be in a state of spastic paralysis, with exaggeration of knee-jerks and well-marked extensor plantar response.

In addition, retraction of the head and neck, or stiffness of the neck muscles, will be observed if the upper cervical nerves are irritated. Purposeless yawning is said to be pathognomonic of cerebellar tumours.

*Treatment.*—Previous to discussing the question of operative treatment a warning may be given against a too ready diagnosis of gummatous disease of the brain. Gummata are amongst the rare types of brain tumour. Again, many gummata in this region are totally unaffected by antisyphilitic treatment of all sorts. Consequently, if gummatous disease is diagnosed on reasonable grounds, and if no radical improvement takes place within a few weeks, other treatment must be adopted.

The *treatment* of brain tumours is *radical* or *palliative*—the former carried out in the hope of removing the tumour, the latter in the anticipation of relieving the symptoms. A palliative decompression, carried out at the right time and in the right manner, will cure the papillœdema and save the sight, will put an end to headache, will stop the vomiting, and will generally improve the patient's condition, not for months only, but, in some cases, for years. These points are worthy of the greatest consideration.

The **radical** operation is obviously the more ideal, but, unfortunately, it is seldom practicable. It has been estimated that not more than about 5 per cent. of tumours are removable—that is to say, situated in such a position and so constituted as to be removed by surgical means. Still, it is usually impossible to determine whether the tumour can be removed unless it is seen. The operation, therefore, even when intended to be radical, is rather of the nature of an exploration. If the tumour cannot be removed when fully exposed the surgeon must remain content with a secondary decompression—secondary in distinction to an operation carried out with the primary object of decompression.

In the radical treatment of a *cerebral* neoplasm the tumour must be exposed by osteoplastic flap (*craniotomy*) (see p. 455). The dura may be opened at the same operation, but as a general rule it is advisable to conduct the operation in two stages. At the first stage the bone flap is framed, replaced, and anchored in position by a few sutures. At the second the flap is again turned down and the dura mater opened and the tumour removed. The dura is then sewn up and the osteoplastic flap replaced and sewn in position.

A *cerebellar* tumour, on the other hand, is exposed by trephining over the cerebellum and cutting away such bone as is required (*craniectomy*). It is difficult to frame an osteoplastic flap in the cerebellar region, and, in addition, such measures handicap the surgeon, who is already greatly cramped in his exposure of the subtentorial space. Even after an extensive removal of bone,

the view obtained of the cerebellum is very confined and the friable brain substance bulges out through the aperture, thus still further increasing the difficulties.

In all these operations it should be borne in mind that there must be no hurry. Time is of little importance so long as the patient is not allowed to lose blood. Shock is, to all intents and purposes, directly proportional to the amount of blood lost. The measures to control hæmorrhage are dealt with at p. 455.

**Palliative operations: Primary decompression.**—When the operation is carried out with the deliberate intention of decompression only, three courses are available—*subtemporal decompression*, *cerebellar decompression*, and *decompression immediately over the site of the tumour*, if that site can be diagnosed with accuracy. All these methods are described at the end of this section. Each presents certain advantages and disadvantages. Thus *subtemporal decompression* is a safe operation and usually suffices to bring about the desired result. However, the opening made in the skull is of no large size, and, in addition, it is of little use if the tumour be situated beneath the tentorium. Still, the operation can be conducted on both sides of the skull. If on one side only, the decompression should be carried out on the side of the tumour and, if the tumour is not definitely localisable, on the right side, thus avoiding any possibility of including Broca's convolution in the hernial protrusion.

FIG. 159.—A case of bilateral subtemporal decompression for tumour of the brain.

*Cerebellar decompression* is more adapted for the relief of cerebellar tumours. The operation, however, is not devoid of danger. During the administration of the anæsthetic the patient may stop breathing. If this happens, the skull must be opened with the greatest rapidity, after which artificial respiration is carried on. The opening should be a generous one—on the side of the tumour and, in case of doubt, on both sides.

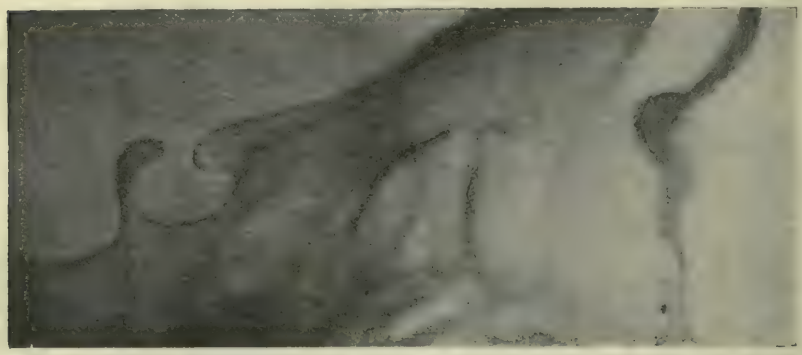
*Decompression over the site of the tumour* undoubtedly affords the greatest degree of decompression. It is the operation chosen for cerebellar tumours, as described above. It may also be carried out for a cerebral neoplasm, but then it presents the very great drawback that, if conducted in relation to the motor areas, the brain will protrude through the gap and spastic paralysis will at once develop on the opposite side of the body, associated with loss of speech in the event of a left-sided operation. This is not a desirable result and should be avoided. This herniation, however, of the motor cortex may sometimes be prevented by carrying out osteoplastic resection followed by subtemporal decompression.

Taking all these facts into consideration, it would appear that *subtemporal decompression* is the operation of choice for cerebral tumours and *cerebellar decompression* for subtentorial neoplasms.

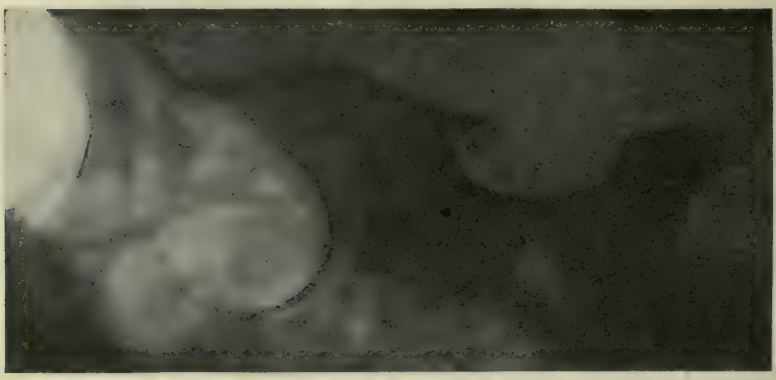
In all cases it is absolutely essential that the dura mater should be freely opened; the mere removal of bone is not enough. In osteoplastic resection the dura is left open and the bone flap replaced; in subtemporal decompression the dura is left open and the gap protected by the approxima-

tion of the temporal muscle fibres; in cerebellar decompression the dura is left open and the gap closed over by means of the strong nuchal muscles.

The details of this operations are given at the end of this section. It suffices to add that a properly conducted decompression operation produces very satisfactory results, often curing the papilloedema, greatly relieving the headache, and generally improving the condition of the patient—for months to years. In addition, it may be urged that the radical treatment of brain tumours is so unsatisfactory that surgical measures are rather tending



(*a*) Skiagram showing a normal pituitary fossa.



(*b*) Skiagram showing an enlarged pituitary fossa from a case of acromegaly.

FIG. 160.

towards palliative treatment by means of these decompression operations in preference to radical attempts at tumour removal.

## Tumours of the Pituitary Body.

The pituitary body is developed in two parts—the *anterior* (pars glandularis) as an upgrowth from the pharyngeal epiblast, the *posterior* (pars nervosa) as a downgrowth from the neural epiblast. The two fuse together to form the pituitary body. The gland retains an attachment to the floor of the third ventricle by means of its stalk or infundibulum.

The pars glandularis has an internal secretion which passes straight into the surrounding venous plexus and so into the general circulation. The

pars nervosa has another secretion which passes into the channel of the infundibulum and so into the ventricular cerebro-spinal fluid, from which it is absorbed into the general circulation.

It is probable that the two secretions have entirely different functions,

Fig. 161.—A large pituitary tumour (cysto-adeno-sarcoma). (St. Bartholomew's Hospital Museum.)

the anterior exercising considerable influence on skeletal growth, the posterior being mainly concerned in tissue metabolism, vascular tone, etc. In any case, there is evidence to prove that the pituitary body is essential to life. Its removal in dogs is invariably followed by death within a few days.

Tumours of the body vary in their pathological character. There may be simple hyperplasia of the gland, but such conditions are rare, and it is more usual for the tumour to be adenomatous, cystic or sarcomatous.

The gland is covered above by the diaphragma sellæ, a dural sheet attached to the four clinoid processes. Enlargement of the gland, therefore, takes place with difficulty in the upward direction. By preference it erodes its osseous boundaries, especially in the downward direction, towards the sphenoidal air sinus and pharyngeal roof, this change being recognisable on X-ray examination.

*Symptoms.*—The rather complex syndrome of symptoms is best considered under the following heads :—(1) *Neighbourhood symptoms*, due to the pressure of the enlarging body on the structures in anatomical relation, and (2) *secretory or glandular symptoms proper.*

**Neighbourhood symptoms.**—(1) *Headache*, a very constant symptom, sometimes general, but more often bitemporal. It is due to the pressure exerted on the tight membranous capsule enclosing the gland, and to some slight increase in the general intracranial tension.

2. *Visual disturbances*, due to the pressure exercised on the optic chiasma and nerves. Two main conditions result—*optic atrophy*, without antecedent papillœdema, bilateral but seldom symmetrical, or *bitemporal hemianopia* (blindness of both nasal halves of the retina). The latter condition may be regarded as almost pathognomonic of a pituitary tumour (see Figs. 180 and 182, pp. 496 and 497). More evidence is required before a definite statement can be made as to which of these two states is the more common. Other visual disturbances are photophobia, proptosis, squints and pupillary alterations (from involvement of the third, fourth, and sixth nerves), and nystagmus.

3. *Anosmia*, from pressure on the olfactory tracts.

4. *Trigeminal neuralgia*, from pressure on the fifth nerve.

5. *Epistaxis*, *discharge of mucus* from the nose, and *cerebro-spinal discharge* from the nose (rhinorrhœa), these symptoms generally indicating the extension of the growth to the sphenoidal and nasal regions.

**Glandular symptoms.** (See also Section III , p. 179.)—As previously stated, the anterior or glandular portion of the gland presides over the skeletal growth, the posterior over tissue metabolism, vascular tone, etc. Though each possesses these main functions, there are others less definite. In any case, it is clear that glandular hyperplasia or disease may result in increased or decreased secretion from one or from both parts of the gland. For example, there may be hyperactivity of the one and insufficiency of the other. In consequence, a varied train of symptoms may result.

When these are analysed, three main groups present themselves :—

1. Predominant hyperpituitarism.
2. Predominant hypopituitarism.
3. Mixed or transitional cases (dyspituitarism).

**Predominant hyperpituitarism.**—Two conditions may be observed illustrating the effects of hyperpituitarism, according to whether the glandular over-activity develops during or after adolescence. In the first case the glandular excess so stimulates the growth of bones and tissues in general as to result in the production of a *giant.* This individual, though of considerable height and possessing a more or less massive frame, has no proportionate muscular strength and is of very moderate intellectual development. The pituitary fossa is considerably enlarged, as seen on X-ray examination. These giants seldom live beyond middle age.

When the glandular excess develops later in life *acromegaly* results, a condi-

tion associated with enlargement of the hands, feet, lower jaw and other bones of the face, thickening of the tongue, broadening of the nose and nasal passages, coarsening of the skin, increased secretion of sebaceous glands, and falling out of the hair. The sexual glands, though sometimes over-active in the earlier stages of the disease, soon become more or less functionless.

**Predominant hypopituitarism.**— Diminution of glandular secretion occurring early in life results in the production of a curious condition known as *dystrophia adiposagenitalis* (Fröhlich's syndrome). Here there is an extraordinary carbohydrate tolerance, the patient becoming exceedingly fat. Polyuria is the rule, but there is little or no sugar in the urine. In addition the general characteristics of infantilism are predominant, great retardation

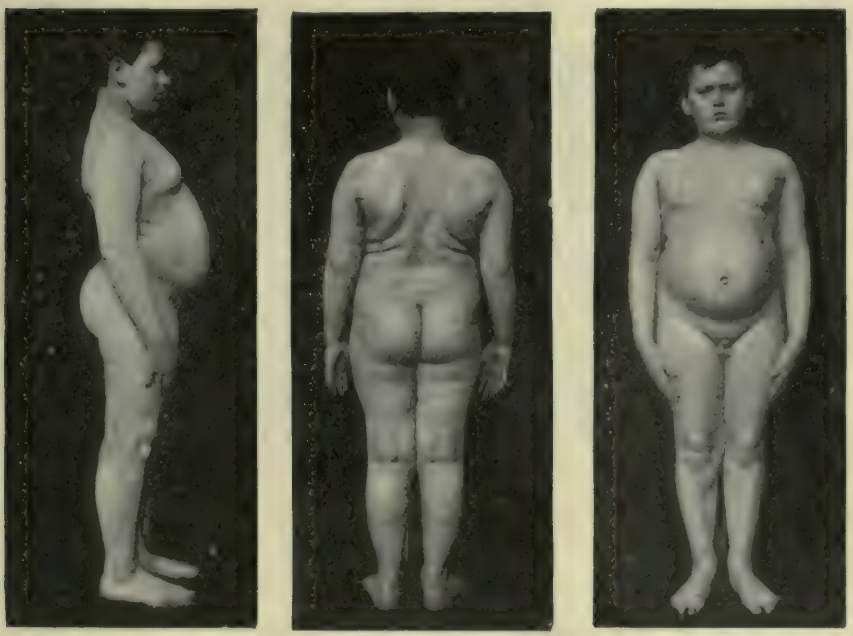


FIG. 162.—Three photographs of a case of Fröhlich's syndrome (dystrophia-adiposa-genitalis), kindly lent by F. E. Batten, Esq., F.R.C.P.

of skeletal growth, absence of pubic and axillary hair, small generative organs, absence or diminution of sexual desire, and a small child-like voice.

When occurring later in life the male loses his masculine characteristics; muscular power wanes, mental capacity deteriorates, and fat is deposited in large quantities, more especially in such regions as tend to become adipose in the female, mammary region, lower abdomen and pubic regions, and in the thighs. The back tends to become kyphotic and the genital organs atrophy, with corresponding loss of sexual power and desire. The female puts on excessive fat in the situations mentioned above. In other respects the changes in the two sexes are similar.

In both sexes the sweat glands become less active and the skin is soft, the hands are tapering (contrasting markedly with the short, blunted, spade-like hands of the acromegalic), and the hair is fine and silky.

In both hyper- and hypo- pituitarism mental deterioration is the rule. In the *transitional stage of dyspituitarism*, any combination of symptoms may

be present. For example, a primary acromegalic may evidence at any time a state of increasing glandular insufficiency, showing a great advance in carbohydrate tolerance and putting on fat in the characteristic positions mentioned above, etc.

*Treatment.*—First of all it is probable that operative interference can only be considered in the event of excessive secretion, with consequent gigantism and acromegaly. Even in these two conditions the surgeon may hesitate to advise operation unless symptoms are developing which point to pressure on the optic chiasma, with the secondary risk of optic atrophy and more or less complete blindness. Headache is another symptom, which may be so severe as to call for radical treatment.

Two types of operation have been carried out—(1) a *direct attack on the*

FIG. 163.—The " spade-like " hands of an acromegalic.

*gland* in the anticipation of removing such portion as will neutralise the over-production and alleviate the ocular and other symptoms, and (2) a *subtemporal decompression*, on one or both sides, to relieve the symptoms in general. Both operations have met with some success.

Subtemporal decompression is described below (p. 457). It presents but little danger and may greatly improve the patient's condition.

Various methods of direct attack on the gland have been advocated and carried out. The one that has met with the greatest measure of success is known as the trans-sphenoidal method, the gland being approached by submucous resection of such portion of the nasal septum as is required to expose the under surface of the body of the sphenoid. The sphenoidal sinus is broken through and the gland exposed. The surgeon may then rest content with such a " sellar decompression," or a portion of the gland may be curetted away.

In cases of hypopituitarism beneficial results have been obtained by feeding the patient with pituitary, thyroid, and testicular extracts.

## CRANIO-CEREBRAL TOPOGRAPHY AND TECHNIQUE OF OPERATIONS ON THE SKULL AND BRAIN.

### Cranio-cerebral Topography.

The skull may be divided into two halves by a line drawn from the base of the nose (the nasion) to the external occipital protuberance (the inion),

this representing the attachment of the *falx cerebri* and the *superior longitudinal sinus*. Each half of the skull can be subdivided by the surface marking of the attachment of the *tentorium cerebelli* and the *lateral sinus*. These are represented by a line, presenting a slight upward convexity, from the upper and posterior part of the mastoid process to the external occipital protuberance. The *cerebellum* lies wholly below this line, its two lobes being separated from one another by the *falx cerebelli*, which corresponds to a line drawn vertically downwards from the external occipital protuberance.

On that area of the skull which lies above the lateral sinus the following structures may be depicted—the middle meningeal artery, the level of the base of the brain, and the more important fissures and cortical areas of the brain.

**The middle meningeal artery.**—This artery, after entering the skull through the foramen spinosum, soon divides into two main branches, anterior and posterior. The anterior is the larger and the more liable to injury. The main danger zone in the course of this vessel may be mapped on the surface by taking three points, the first of which lies 1 inch behind the external angular frontal process and the same distance above the zygoma, whilst the other two are situated respectively 1½ and 2 inches behind and above the same landmarks. The anterior branch of the artery may be exposed by trephining over either of these selected sites, but the higher point, the 2-inch one, is the site of election for trephining. The posterior branch of the artery passes backwards parallel to, and about 1 inch above, the upper border of the zygoma.

**The base of the cerebrum.**—A point is taken about ½ inch above the nasion, and from this a line is drawn outwards which lies about ½ inch above, and follows the curve of the upper border of the orbit. This line is carried outwards as far as the external angular frontal process, then curving upwards and backwards to the *Sylvian point*, the site of divergence of the three limbs of the Sylvian fissure. This is situated 1¼ inches behind the external angular frontal process and 1½ inches above the zygoma. The temporo-sphenoidal lobe now sweeps downwards and forwards towards the posterior border of the malar bone and then passes backwards level with the upper border of the zygoma. At and behind the ear the brain lies flush with the suprameatal and supramastoid crests, subsequently following the curve of the lateral sinus.

From the Sylvian point the main posterior limb of the *Sylvian fissure*, separating the temporo-sphenoidal lobe below from the frontal and parietal lobes above, passes backwards and upwards to a second point situated ¾ inch below the parietal eminence.

**The fissure of Rolando.**—A point is taken ½ inch posterior to the central point of a line drawn across the vertex of the skull from nasion to inion, and from this a line is drawn downwards and forwards, for from 4 to 5 inches, in a direction towards the centre of the zygoma. This line is inclined to the median antero-posterior line at an angle of 67½ degrees (three-quarters of a right angle).

**The cortical motor and sensory areas.**—The cortical motor area occupies the pre-central convolution, entirely anterior to the Rolandic fissure. It spreads well over on to the mesial aspect of the brain and in the downward direction to within a short distance of the Sylvian fissure. In front the motor area has a more indefinite boundary though it includes some of the pre-central convolution. The motor strip is, on an average, not more than ¾ to 1 inch in breadth. It corresponds, from above downwards, to the movements of the contra-lateral lower extremity, trunk, upper extremity, neck and

face. On the left side of the brain, in right-handed individuals, *Broca's motor speech area* is situated, in the angle between the anterior and posterior limbs of the Sylvian fissure.

The registration of *common sensation* takes place in the post-central convolution, occupying a position similar in extent to that representing the motor area in front of the Rolandic fissure. It is probable that sensation in any given part lies on more or less the same level as the corresponding motor area.

The perception of *muscle sense* is probably received in the area immediately posterior to that responsible for tactile registration. *Stereognosis*

FIG. 164.—The application of the scalp-tourniquet—front view.

(memory pictures, object perception, etc.) is referred to the upper part of the parietal lobe.

*Primary visual impressions* are received in the occipital lobe and *smell and taste* in the anterior pole of the temporo-sphenoidal lobe.

Finally, the four areas concerned in *speech*. The actual power of speaking is related to the area of Broca on the left side, in the angle between the anterior and posterior limbs of the fissure of Sylvius. Writing, so closely connected with speech, lies immediately above Broca's area, in the lower portion of the pre-central motor strip. Auditory impressions are received in the posterior part of the first temporo-sphenoidal convolution, and the power of reading is dependent on the integrity of the supramarginal and angular gyri.

## Some Points in the Technique of Operations on the Skull and Brain.

**Preparatory treatment.**—In many operations it is advisable to administer, half an hour previous to the operation, a hypodermic injection of a quarter of

a grain of morphia and a hundredth of atropin. By this measure it is anticipated that shock will be diminished in intensity. The anæsthetic should be open ether or chloroform.

In order to minimise the possibility of infection the head should be covered with gauze, three or four layers thick and of sufficient size to cover all parts except the face.

It is absolutely essential for the success of the operation that hæmorrhage should be controlled throughout. Bleeding from scalp vessels may be very troublesome, and ligatures are difficult of application. There are two methods whereby this object may be attained -by the utilisation of the scalp-tourniquet or by hæmostatic clips.

The *scalp-tourniquet* consists of a rubber band passed tightly round the head, fitting low down over the occipital region, above the ears and across the forehead, and fastened in front. A median tape, from nasion to inion, prevents the tourniquet from slipping down over the eyes. The main objection to the scalp-tourniquet lies in the fact that it cannot be utilised in operations conducted in the temporal and cerebellar regions.

The membranes and brain may be exposed by craniectomy or craniotomy.

**Craniectomy** implies the formation of a scalp flap, exposure of the bone, trephining of the skull, and enlargement of the gap according to requirements.

After the scalp flap is framed, the pericranium is stripped aside and the skull trephined. Trephines are driven by a motor or worked by hand. The latter method, though slow, is much the safer.

The dura is separated from the bone and the gap enlarged, according to requirements, with biting or nibbling forceps. An extradural clot may now be washed away. In most cases, however, the dura must be opened, either by crucial incision or by flap formation. In either case any branches of the middle meningeal artery that cross the line proposed for dural section must be underrun with a fully-curved and threaded needle and the vessels ligatured on either side. On incising the membrane great care must be taken to avoid injury to the underlying, often markedly engorged, cerebral veins. The dura is incised lightly with the knife and the section completed with the aid of a director or with blunt-pointed scissors.

**Craniotomy or osteoplastic resection** implies the formation of a flap of scalp and bone in one, and the exposure of an area of dura and brain proportional to the size of the bone and scalp flap. A \ / -shaped incision is made through the scalp down to the bone and, at the two upper angles, trephine holes are made. Between them Gigli's director is passed, entering at one hole, emerging from the other, and lying throughout between the dura and the bone. Over this Gigli's saw is introduced and the bone sawn through, not directly to the surface, but in a shelving manner so as to allow of a ledge on which the bone flap may rest when replaced. At the lower ends of the two vertical incisions two more holes are made and the bone divided, or a narrow channel may be cut with de Vilbiss's forceps. The three sections being completed, the flap is lifted up, broken across at its base, and thrown back. Thus a large area of dura is exposed, proportional to the size of the flap.

The opening of the dura is carried out at the second stage of the operation, about a week later. Consequently, after the termination of stage 1, the bone flap may be replaced and anchored by means of a few sutures.

A week later it is turned down again, the dura opened, and the requisite intracranial procedure carried out. The dura should be sewn up again, if circumstances permit, and the flap replaced and anchored with sutures.

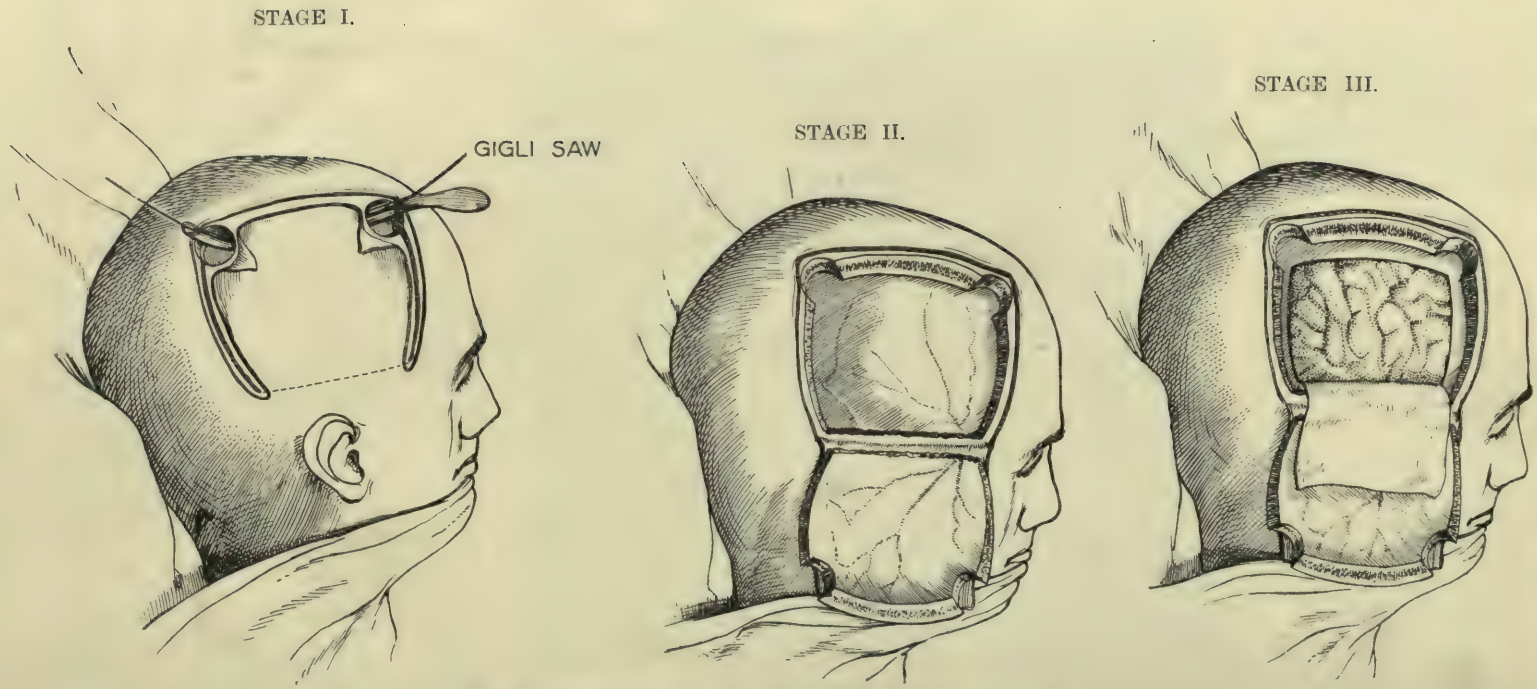



FIG. 165.—The three stages in osteoplastic resection of the skull.

**Subtemporal decompression.** This operation is carried out by preference under local anæsthesia, to prevent vomiting after the operation—absence of vomiting is greatly to be desired in all head cases.

A curved incision is made below, and following the line of, the temporal crest, and the cutaneo-muscular flap turned down towards the base of the skull. When all bleeding has been controlled, the trephine is applied to the centre of the bone exposed, and a disc removed. With the help of nibbling forceps, the bone is cut away freely in the forward, backward, and especially in the downward directions, until a large opening is made.

Meningeal vessels crossing the dura are underrun and tied, after which the membrane is incised in a crucial manner right up to the margins of the bone.

This permits of the escape of excess of cerebro-spinal fluid in cases of cerebral œdema, of blood in subdural hæmorrhages, and permits also of the requisite relief of the increased intracranial pressure of cerebral tumours.

The cut edges of the temporal muscle are approximated with catgut sutures, and the skin edges united.

# Section IX.

## DISEASES OF THE EAR.

**Physical examination.**—The complete examination of the ear includes visual inspection (otoscopy) and the testing of the permeability of the Eustachian tube, the investigation of the cochlea (hearing power), and of the vestibular section of the labyrinth, and finally the examination of the mastoid, and of the lymph glands which drain the area of the external and middle ears and mastoid process.

*Visual inspection.*—A good light is needed for satisfactory examination; while strong diffused daylight may be used, an artificial light is preferable and it is advantageous to have it intensified by a projector. The patient is seated between the surgeon and the light, with the affected ear towards the surgeon. The light is thrown on the ear by a forehead mirror. The pinna and its surroundings are first examined and any abnormal condition noted before the speculum is introduced. To introduce the speculum, the auricle is lifted somewhat upwards and backwards between the index and middle fingers of the left hand, and the speculum, held between the thumb and first finger, is gently pushed in with a rotatory movement, being carried only so far as to open fully the cartilaginous meatus. Any small obstacle to a free view of the fundus is removed by gently wiping with cotton-wool wrapped on aural forceps; if full inspection cannot be readily obtained in this way, it is best to syringe out the meatus with warm lotion and dry thoroughly with cotton-wool. It is absolutely necessary that the ear should be clean before any attempt is made to diagnose its condition. In the normal ear the membrana tympani can now be seen occupying the fundus; it appears as a bluish or yellowish grey sheet, semitransparent and of a high surface polish. Its most conspicuous features are the processus brevis and handle of the malleus, the former showing as a small conical white elevation close to and a little behind the middle of the upper margin, the latter as a white streak passing downwards and backwards from the processus brevis to a point just below the centre of the membrane. From the tip of the malleus a triangular light reflex extends downwards and forwards for a variable distance with its base to the periphery. If the ear has been syringed or wiped there is frequently a conspicuous leash of vessels to be seen passing from the roof of the meatus along the posterior border of the handle of the malleus towards the centre of the membrane; it must not be mistaken for a sign of inflammation. Above the short process the upper margin of the wall of the meatus is indented by the notch of Rivinus; the part of the membrane which fills this and lies above the level of the processus brevis is thin and lax, and is the membrana flaccida of Shrapnell. The view of the fundus may be prevented by cerumen, polypus, or swelling or new growth of the meatal wall. The most important pathological conditions to be noted in the membrane are perforations, which may be so large as to expose the inner tympanic wall freely, opacities, scars, and abnormalities of position.

The mobility of the membrane and malleus may now be tested by means of the pneumatic speculum, and the presence of adhesions or thin retracted

scars ascertained. The permeability of the Eustachian tube is investigated by forcing air from the pharynx into the tympanum, and estimating the effect either by watching the movement of the membrane or by means of the diagnostic tube. This is simply a length of stout-walled rubber tube with a suitable piece at each end to fit the ear of the patient and surgeon respectively; the sound of the passage of air is conveyed directly to the examining ear. The forcing of air through the Eustachian tube is effected either by Valsalva's method, by Politzer's method, or by the Eustachian catheter.

*Valsalva's method* consists in making forcible expiration with the mouth and nose closed and the cheeks distended.

*Politzer's method* forces the air by means of an indiarubber bag and tube, the end of which is introduced into one nostril while the other nostril is closed and the first made airtight round the tube. At the instant of compression of the bag the palate must be elevated against the posterior wall of the pharynx; this may be effected by the patient filling the cheeks with air, by his swallowing a mouthful of water, or by the utterance of some guttural sound such as "huck."

*To pass the Eustachian catheter* the instrument is lightly and rapidly introduced through the inferior meatus of the nose with its beak downwards until the point is felt to pass over the soft palate and touch the posterior wall of the pharynx; it is slightly withdrawn to free it from the mucous membrane and rotated so that its point looks directly inwards, when it is further withdrawn until the curve engages with the posterior edge of the vomer; finally it is rotated so that the point sweeps downwards and then outwards over the soft palate to a position in which it looks upwards and outwards towards the outer canthus of the eye of the same side. Further rotation is arrested if the catheter be in correct position by the hooded margin of the Eustachian cushion. If this method fails, trial should be made by turning the point outwards after its withdrawal from contact with the posterior pharyngeal wall, and gently withdrawing until it is felt to slip over the margin of the Eustachian cushion; it is then slightly rotated upwards and pushed gently inwards for a short distance when the point will lie in the orifice. The passage of the catheter is always an unpleasant ordeal to the patient; in cases of difficulty from narrowness of the inferior meatus, it is much facilitated by the preliminary use of a 10 per cent. cocain solution, which both reduces the thickness of the mucosa and allows of freer manipulation. If it is found impossible to reach the mouth of the Eustachian tube through the nostril of the same side, an attempt may be made with a catheter of longer curve through the opposite nostril.

When the catheter is in position, the ear is inflated by the gentle use of a Politzer's bag, the nozzle of which is applied to the catheter. Before this is done, the auscultatory tube should be placed in position, so as to connect the ears of the patient and surgeon. Through the normal Eustachian tube the air passes with a sharp dry sound; narrowing of the tube is shown by the prolongation and feebleness of the sound, which in active catarrh becomes squeaky or bubbly in character. If an open perforation be present, the air passes through it with a clear whizzing, and the current is felt to impinge directly on the observer's membrane.

It is important for diagnostic purposes to determine the hearing distance for the acoumeter or watch before inflation of the tympanum is attempted.

*Investigation of hearing.*—The determination of hearing power is still in an unsatisfactory position; the voice is uncertain both in pitch and volume; the acoumeter and watch are too high-pitched to afford a useful criterion;

while the use of forks gives no information of the power of definition of sound-form. The voice is used to determine the greatest distance at which words can be apprehended when spoken in a low conversational tone and when the "voiceless" whisper is used. The acoumeter is preferable to the watch as furnishing a sound of standard pitch and loudness, and is useful for purposes of comparison from time to time. The most important tests for diagnosis are made with the tuning forks. With the sounding fork, which should be not lower than 256 nor higher than 512 double vibrations in the second, placed on the middle line of the forehead, the sound will be heard equally through both sides when conditions of hearing are symmetrical; when one ear is affected by a deafness of middle-ear origin or one due to obstruction in the external meatus, the sound will be more loudly heard in the affected ear; when the sound is more loudly heard in the unaffected ear, the deafness is of labyrinthine type. This is *Weber's test.*

In a normal ear a tuning fork of middle pitch is heard at the meatus after the sound has been lost with the fork on the mastoid; this still holds in deafnesses of labyrinthine type, but the converse is true of middle-ear deafness, in which the fork is heard on the mastoid after it ceases to be audible at the meatus. The comparison in this way of the hearing by air conduction and through the bone is known as *Rinne's test.* The appreciation of low tones is tested by tuning forks of slow vibration frequency, that of high tones by high forks, by Galton's whistle, and best by the monochord.

**Physical tests of the labyrinth.**—Our knowledge of the vestibular section of the labyrinth has been much increased of recent years by the researches of Bárány and others. The most important methods used are thermal stimulation by hot and cold water and rotation of the patient on a special turning table. The results obtained are often of the greatest importance, but the application of the methods requires a high degree of special knowledge. By the use of these tests the integrity or otherwise of the membranous labyrinth can be definitely ascertained.

To complete the investigation of a case of disease of the ear it is often necessary to examine the nose and naso-pharynx (see p. 717). It is wise to make this a routine in every case.

## Diseases of the Pinna and External Meatus.

**Eczema** may be acute or chronic and may be part of a general affection or restricted to the ear. In the acute form there is great redness and swelling of the pinna, with some tenderness. There is a brief vesicular stage, followed by serous exudation which tends to form crusts, beneath which there is an excoriated red moist surface. The chronic form is often accompanied by great thickening of the pinna, which may be in part permanent; the surface is dry unless there are fissures, the scales are formed by an admixture of dried serum and epithelial flakes; the meatus is always involved and the disease may be restricted to it. In the meatus the presence of partially detached epithelial flakes may give rise to insufferable irritation. There is often some feeling of fulness and obscuration of hearing with slight tinnitus. The condition may prove very obstinate, and is often complicated by furunculosis.

*Treatment.*—It is advantageous in all cases to bathe the ear well with warm water and a non-irritant soap. If there is discharge from the tympanum, as is frequent in acute cases, it must be appropriately treated. In the acute

stages, lead lotion or the lot. calaminæ co. or a powder of zinc oxide and calomel may be used; in obstinate cases, trial may be made of silver nitrate (gr. xx. to the ounce), painted on once and followed by free exposure to the air. Boracic acid powder is best avoided. In the chronic stage a weak ointment of ammoniated mercury or ichthyol gives good results. The removal of scales from the meatus is facilitated by the use of alkaline drops (sod. bicarb. gr. xx. to the ounce). Much relief from irritation can be given by an ointment of cocain and atropin, but this should not replace rational treatment. The general conditions should receive attention.*

**Erysipelas** of the pinna is not rare. It usually originates in an infected crack at the entrance of the meatus and may spread over the face and neck. It should be treated on the same lines as erysipelas elsewhere, with proper attention to any discharge which may be present.

**Hæmatoma auris** is said to occur spontaneously in the insane and may be produced by injuries such as are sustained in boxing and football. It appears as a hard, usually non-fluctuant swelling on the front of the upper part of the auricle, which may be of a bluish hue; there is not usually much pain. Later, shrinkage may take place, but the tumour rarely disappears entirely, and deformity may be left. If infection and suppuration take place, necrosis of the cartilage is almost certain and great deformity of the pinna usually results.

*Treatment.*—If seen in the early stages, the increase of the effusion may be minimised by an ice-bag; puncture is of use only before the swelling has become hard; if employed, it must be with the most careful asepsis. A suppurating hæmatoma should be freely opened and fomented.

**Congenital malformation** of the auricle may be of any grade, and is due to arrest of development and fusion of the tubercles which spring up about the entrance of the external part of the first post-oral visceral cleft. In the milder cases the external meatus is present and the tympanic structures and labyrinth are normal: in more severe deformities, the external meatus is atresic, and there may be an entire defect of the inner half of the cleft (Eustachian tube and tympanum).

*Treatment* is in suitable cases by plastic operation, which must be devised to meet the possibilities of the particular case.

**Undue prominence** of the auricles is caused by an abnormal hollowing of the external aspect, often with absence of the antihelix. Much improvement may be effected by plastic operation and drawing back of the pinna into closer contact with the mastoid. Subsequently care must be exercised to maintain the ear in the improved position by a suitable earcap.

**Sebaceous cysts** are not uncommon, their most frequent position being on the posterior aspect of the lobule. They should be removed by dissection.

**Keloid of the lobule** may occur in the puncture made for wearing ear rings.

**Ulcers of the auricle** may be circulatory, syphilitic, or malignant. The circulatory ulcer is due to exposure to cold, and is one of the manifestations of Raynaud's disease, in which case it is usually symmetrical, and may be a part of a gangrenous process. It should be treated by surgical cleanliness and kept dry and warm.

Syphilitic ulceration of the pinna is rare; it may lead to rapid destruction of a large part of the auricle, and occurs in the tertiary period. It should be energetically treated on general lines with local antiseptic dressings.

* Cultivation from the serous exudate will very often show an almost pure growth of staphylococcus aureus. In such cases very great improvement will be obtained by the use of a vaccine, commencing cautiously with doses of five to ten million.

Malignant ulceration is due to squamous-celled carcinoma, or to rodent ulcer; it usually attacks the upper part of the pinna. Its nature should be ascertained microscopically before treatment is undertaken. In rodent ulcer, treatment by X-rays should be tried before surgical measures. Squamous carcinoma requires free removal with the mastoid and preauricular glands in all cases, and in advanced cases a set operation on the glands in the triangles of the neck. Whenever possible, the external meatus should be spared.

**Furuncle of the meatus** is due to staphylococcal infection of a follicle and always occurs in the cartilaginous part. For the most part, there is no obvious local cause. In many cases the patient is anæmic and overworked. Furuncles often occur in series. Pain may be excessive, and there is often considerable constitutional disturbance. On examination, a swelling or swellings will be found in the outer part of the meatus, which may be completely blocked: there is little or no redness. The preauricular gland is almost always tender, and may be obviously swollen; suppuration in or about the gland is very rare. Œdema may spread to the mastoid, and occasionally suppuration burrows back into this region; very rarely pus makes its way forwards into the parotid region. Many furuncles run their course without the formation of pus.

*Treatment.*—In the early stages, before suppuration, much relief may be obtained from the introduction of a cotton-wool bougie soaked in pure glycerine; externally, an ice-bag gives much comfort and appears to aid in the abortion of suppuration in many cases. When pus has formed, a free incision should be made under a general anæsthetic, and the interior of the furuncle curetted to remove any slough. Whenever pus is present the ear should be kept well syringed and cotton-wool forbidden. Where successive furuncles appear, treatment by vaccine is very successful in cutting short their recurrence, and should be always undertaken.

**Dermatitis of the meatus** may be acute or chronic. The acute form is accompanied by general swelling and a sense of fulness and throbbing with some deafness. It results from a skin infection which may have a definite origin in a crack or scratch; sea bathing is said to act as a predisposing cause. The membrane may be involved. The surface of the meatus is at first red, then whitish from the formation of a layer of sodden epithelium, which later desquamates. There is a serous or purulent discharge, never mucoid. The condition is distinguished from a multiple furunculosis by the involvement of the superficial layers of the skin.

*Treatment.*—The ear should be kept clean by syringing with an alkaline lotion and epithelial *débris* removed by gentle swabbing with cotton-wool. Very good results are obtained by the use of lot. calaminæ co. or of lead and opium lotion in the acute stages; when the condition becomes chronic, ammoniated mercury ointment or a coal-tar lotion may be used with advantage.

**Cerumen** by its accumulation in the meatus may completely occlude it, causing a high degree of deafness. When a hard plug exerts pressure on the meatal wall and membrane, pain, loud tinnitus, and vertigo may be caused in addition to the deafness. It is characteristic for the deafness to have a sudden and painless onset. A ceruminous plug may be of any colour from that of honey to an almost complete blackness. The commonest cause of accumulation of cerumen is the making of fruitless attempts at its removal with a towel.

*Treatment.*—If the wax is hard, it may first be softened by the use of a

warm solution of sod. bicarb. (gr. xx. to the ounce) or by dropping in peroxide of hydrogen solution (x. vol. strength). If soft, it may be at once removed by syringing with warm water. The pinna should be drawn upwards and backwards and the stream of water directed along the upper and posterior wall of the meatus. After syringing, the meatus should be well dried, and a careful examination of the membrane made; a note should also be made whether satisfactory hearing has been restored.

**Otomycosis.**—This disease is rare in England, and when seen it is generally in natives of India. It is caused by a parasitic fungus (*Aspergillus niger*), which grows between the epithelial cells. The black variety of the fungus is sometimes replaced by a sulphur-yellow one, but the characters of the disease remain the same. The only symptom produced is as a rule a feeling of irritation and fulness due to the desquamation present. There may be a serous discharge. The disease is extremely obstinate.

*Treatment* should be by cleansing the meatus and instillation of alcoholic solution of perchloride or biniodide of mercury (1 in 1,000), or of alcoholic solution of salicylic acid (4 per cent.).

**Hyperostoses** of the meatus may be diffuse or localised. Those of the diffuse variety lead to a general narrowing of the bony meatus, and in extreme cases to its total closure. Before this condition is reached they give rise to trouble by the constant blocking of the small residual opening by fragments of cerumen and desquamated epithelium. The cause of the condition is unknown. In certain cases the appearances point to a chronic periostitis as the cause. Where there is any irritative condition present it should be corrected. In extreme cases it is necessary to remodel the bony and cartilaginous meatus by a suitable plastic operation.

Localised hyperostoses form smooth, pale, lenticular bosses on the deeper part of the wall of the bony meatus. When single they rarely give rise to trouble, but when double or multiple they occlude the meatus and may cause ulceration at their points of contact. They are direct prolongations of the compact bone of the tympanic plate without any distinct line of demarcation from the normal bone, and are excessively hard. Their removal should be undertaken with great caution, as in unskilled hands the operation is very likely to result in serious damage to the middle ear, and there is risk of complete section of the descending part of the facial nerve.

**Exostoses** of the meatus form pedunculated masses resembling a bony polypus. They are attached to the meatal wall by a narrow base, and are usually easily removed by a curette, snare, or hook. Their structure is cancellous, and they are of inflammatory origin.

**Granulations and sinuses** affecting the meatal wall should always be carefully investigated. They may be due to an unhealed furuncle, or to disease of the bony wall or mastoid, and should be treated according to the diagnosis.

**Carcinoma** of the meatus is of the squamous-celled type. It occurs as a warty growth, ulcerating early, with the production of much pain and a blood-stained purulent discharge. The tympanum is soon involved. The diagnosis is made by microscopical examination, which should never be delayed in suspicious cases.

*Treatment* must be radical by the extirpation of the disease and its lymphatic extensions. The pinna may usually be saved. It is turned downwards on the side of the neck by a skin incision, which passes upwards over the parotid region, curves above the pinna, and descends to the tip of the mastoid. It takes up the pinna, which is detached from the external meatus, and the

skin on either side of it. The tissues, including the parotid fascia, are dissected up from the parotid and from the bone above and behind, and are removed in continuity with the soft parts of the meatus. The whole of the bony walls of the meatus are excised, a wide radical mastoid operation is done, and the growth is followed wherever it is found to have penetrated The glands in the upper part of the anterior triangle should be removed at the same time. The prognosis for these cases is relatively good where the growth has not invaded the region of the tympanic end of the Eustachian tube.

**Foreign bodies** in the external auditory meatus are occasionally introduced by children, the commonest being glass beads. Other foreign bodies found in this situation are old plugs of cotton-wool, tobacco, onion cores, seeds, and insects, fleas, bugs, flies, maggots and caterpillars. The largest foreign body which the writer has met with in the external auditory meatus was a cockroach about $1\frac{1}{4}$ inches long. The nature and size of the foreign body should be carefully made out before attempting its removal. Whenever possible the syringe should be used; much serious damage is sometimes done by instrumental attempts at extraction of bodies which might have remained indefinitely without harm resulting. In difficult cases a general anæsthetic should always be given.

**Earache** may be due to a wide variety of causes—in the meatus, cerumen, furuncle, or dermatitis; in the middle ear, acute catarrh, or suppuration, acute or chronic. It may be referred from a carious tooth, or from disease of the tongue, tonsil, or lateral wall of the pharynx (the possibility of malignant disease as a cause of earache should always be remembered in elderly men), or may be due to Eustachian obstruction secondary to pharyngitis, and frequently to adenoids. For a satisfactory treatment a correct diagnosis is essential.

## Diseases of the Middle Ear and Eustachian Tube.

The diseases of this group can only be properly comprehended by the appreciation of the developmental and pathological continuity of the whole of the inner part of the first post-oral visceral cleft. The Eustachian tube, tympanum, and mastoid antrum form three primitive parts of this pharyngeal diverticulum, and are delimited from each other by their relation to the inner end of the external cleft depression, which gives rise to the external auditory meatus. The mucous membrane lining the tympanum, antrum, and mastoid spaces is in direct continuity with that of the pharynx, from which it is derived, through that of the Eustachian tube. Practically all infections of the intact tympanum take place through the Eustachian tube and originate in the naso-pharynx. In addition, a mere catarrh of the pharyngeal end of the Eustachian tube may, if prolonged, result in most serious damage to hearing.

**Acute otitis media** is due to infection of the tympanum from the naso-pharynx.* The violence of the disease will be determined by the nature and virulence of the exciting micro-organism and by the power of resistance of the patient; it may be no more than a mild catarrh with serous or mucous exudate and little or no local or general reaction, or may result in rapid destruction of the tympanic structures, or even in death from septicæmia, sinus thrombosis, or meningitis. The more serious cases are bacteriologically due

* The exceptions to this statement are rare, and are practically restricted to examples of rupture or penetration of the membrane with infection of the tympanum from without.

to the pneumococcus, the streptococcus pyogenes, and more rarely to staphylococci; the milder are consequent on ordinary "colds," and presumably are due to the organisms associated with them. Serious and destructive otitis media isespecially common in connexion with the acute exanthemata and influenza, in all of which the infection of the ear is usually streptococcal. Adenoids are the most frequent predisposing cause of the milder catarrhs.

*Symptoms and appearances.*—Pain in the ear, some deafness, and tinnitus are common to all cases of acute otitis media, their intensity being to some degree determined by the character of the inflammation. Pain may be very severe and even intolerable, radiating from the ear towards the top of the head and downwards to the shoulder; it may be throbbing or stabbing and is often intermittent. In the most acute cases pain is frequently of short duration as it is relieved by early perforation of the membrane. The relief of tension within the tympanum by perforation or paracentesis always results in a diminution of pain. Swallowing and blowing the nose increase the pain and produce sensations of bubbling or crackling in the ear. Fever may be high; there is headache, constipation, and a feeling of illness in severe cases. In young children there may be alarming meningeal symptoms which generally disappear on incision or perforation of the membrane. In cases of invasion of the labyrinth, there is complete deafness and great giddiness. Such cases run grave risk of meningitis.

The otoscopic appearances vary with the degree of the tympanic inflammation. In mild cases there is some fulness of the membrane with the development of visible radial vessels set round the periphery of the membrane. The vessels along the posterior border of the handle of the malleus are conspicuous, and the handle of the malleus may be difficult to see. The deepest part of the roof of the meatus is congested. In severe cases the membrane is bright or dark red, its anatomical features are no longer to be distinguished, and the limit between the membrane and the meatus may be entirely lost above. There is general bulging in some cases; in others the fulness is limited to the posterior segment. Bullæ may form on the external surface of the membrane, and in the deeper part of the meatus. After twenty-four hours there is desquamation of sodden epidermis in the meatus.

The diagnosis must be made in the slighter cases from a simple Eustachian catarrh; in the more severe, from other conditions associated with redness of the fundus, granulations or polypus, or an exposed and congested inner tympanic wall. In all but the mildest cases the condition of the mastoid should be watched closely.

The course of the disease varies much; both mild and severe cases may be of a duration limited to two or three days, or may be protracted to many weeks: in children particularly, fluctuations may take place, or the condition may be actually intermittent. In mild cases perforation is the exception: improvement usually begins after three or four days, signalled by diminution in pain and improvement in hearing; the membrane becomes less tense, the congestion disappears, and its surface assumes a finely wrinkled appearance. Fluctuations in hearing are common during the stage of recovery, depending on the intermittent opening of the Eustachian tube. If the catarrh of the tube continues, the membrane becomes retracted and the deafness persists or may even increase. Unless the naso-pharynx can be brought into a healthy condition, there is a great tendency to relapses. Perforation may take place through the bursting of the stretched and softened membrane by the effusion in the tympanum: after the relief of tension, improvement is usually rapid. In cases of moderate severity the course is usually more pro-

longed, and an almost stationary condition may be arrived at in which the membrane is congested, thickened, and bulging. Such a condition is one of risk both to hearing and on account of the danger of infection of the mastoid, and calls for energetic treatment. In severe cases perforation generally takes place spontaneously within three days; it should not, however, be waited for. In all cases with high fever, continued severe pain and marked general disturbance, the membrane should be promptly incised; the danger both to hearing and of septic complications is in this way minimised. The discharge, whether consequent on spontaneous perforation or incision, is in the milder cases straw-coloured and serous or mucoid; in the severe acute infections at first blood-stained serum, sometimes appearing to be almost pure blood; later it becomes muco-purulent and finally clear mucus, after which all discharge usually quickly stops. The appearances of the membrane during resolution are the same as those of the period of development, but in the inverse order and with a slower rate of alteration. In children, after the subsidence of the acute condition, the tympanum may remain distended and the discharge profuse, ropy, and muco-purulent: such cases require the provision of free tympanic drainage and the rectification of any abnormal faucial or pharyngeal condition in order to place the tympanum in a favourable position for recovery. After the resolution of the inflammation, the membrane may entirely recover its normal appearance; any opening which may have existed during the period of discharge closes rapidly after this has ceased, and hearing as a rule is completely recovered. In other cases, however, and especially in those subacute and prolonged cases in which the membrane remains in an œdematous and congested state for long periods, permanent changes occur, the most noticeable of which are calcareous opacities and local retractions with or without adhesion of the membrane to the inner wall of the tympanum. Hearing in these cases may be permanently and seriously impaired.

In the acute otitis media of scarlet fever, measles, and diphtheria the prognosis is much less favourable than in that resulting from a non-specific infection. Early perforation is the rule and destruction of the membrane is rapid; necrosis of the incus and more rarely of the malleus may take place with consequent disorganisation of the tympanic mechanism. Infection of the mastoid is disproportionately frequent in scarlet fever, and necrosis of the outer part of the bone may follow. It is the duty of everyone who has charge of a case of one of the specific fevers to do all in his power to minimise the danger of infection of the ears by syringing the fauces regularly with an efficient antiseptic, such as the liquor chlori, and by keeping the nose cleansed with a coarse alkaline spray. The ears should be closely inspected each day. Incision of the membrane should be promptly made if there is evidence of infection of the tympanum, and opening of the mastoid by Schwartze's operation (see p. 476) should be carried out without delay if there is evidence of the backward spread of infection.

Any case of acute otitis media may, under unfavourable conditions of health and in the neglect of proper care, become chronic, the non-perforative passing into a condition of chronic dry catarrh with retraction of the membrane and thickening of the submucous coat of the tympanic lining, the perforative becoming cases of permanently open perforation with chronic tympanic discharge. The risk of the occurrence of continued suppuration is particularly great in those cases associated with the exanthemata.

*Treatment.*—In all cases of acute otitis media, whether perforative or not, the patient should be confined to the house and a smart aperient given; in

children especially, calomel is most valuable in the early stages. The fauces and pharynx must be treated appropriately to their condition, but no operative procedure should be attempted in this region during the acute stage of an otitis media, nor before all active local reaction has come to an end (see the sections on the diseases of these regions). The indications for incision of the membrane are high fever and general signs of serious intoxication, severe and intractable pain, great or continued bulging of the membrane, or threatening onset of mastoiditis. It is always convenient to carry out the operation under a general anæsthetic where possible. Cultures should be made immediately from the fluid which issues from the incision. In incising the membrane it is best to enter the knife below and cut upwards; the incision should be free and should be made through the bulging area, behind the handle of the malleus. The greatest care should be taken to exclude secondary infections; both before and after perforation or incision of the membrane efforts should be made to render and keep the meatus aseptic. For this end the meatus may be lightly plugged with cotton-wool soaked in glycerin of carbolic acid in all cases which threaten to perforate or to need incision, while when discharge occurs the meatus should be frequently cleansed and plugged with aseptic gauze. Bismuth gauze has many advantages for this purpose. The free flow of secretion should be encouraged by the use of fomentations. When the discharge is thick and ropy its removal is facilitated by the use of an alkaline lotion (sod. bicarb. gr. xx. to the ounce); boracic lotion or weak mercurial lotions (perchloride or biniodide, 1 in 4,000) may be used if the discharge is thinner. After syringing, the meatus may be insufflated with boracic acid. At the termination of discharge the meatus should be filled with boracic powder, which should not be disturbed for a week unless it becomes moistened.

*Complications.*—The most common complication of acute otitis media is infection of the mastoid antrum, cells and diploe, and consequent suppurative mastoiditis; when this makes its way to the periosteum, a typical mastoid abscess results. It is not necessary to wait for this, for the indications are clear as soon as there is marked œdema over the mastoid following tenderness. Persistent pain and tenderness over the mastoid may be accepted as sufficient evidence if there is swelling of the deeper part of the posterior meatal wall. The temperature is not necessarily raised. Very commonly the dura mater has been exposed by the erosion of bone either behind or above, so that its outer surface is suppurating and forms a part of the limits of the intraosseous abscess. Occasionally a separate extradural abscess is found. More rarely there occur as complications infection of the labyrinth, meningitis, septicæmia, and infection and thrombosis of the lateral sinus.

**Eustachian catarrh** may be acute or chronic; it is always secondary to some pathological condition of the naso-pharynx, fauces, or nasal fossæ. The recurrent or continued naso-pharyngitis of adenoids is the most important of all conditions causing Eustachian catarrh, owing to the enormous frequency of the condition and the long periods during which it remains operative. The symptoms of acute Eustachian catarrh are some discomfort in swallowing, a stopped-up feeling in the ear, generally accompanied by some tinnitus, and in severe cases definite pain in the affected ear. On examination, the membrane is retracted, with an unimpaired surface, and a pink reflex from the promontory in its central part if the membrane has not undergone thickening from repeated attacks. Deafness is of the middle-ear type, and may be severe. In chronic Eustachian catarrh there is no discomfort; deafness is marked and progressive, of middle-ear type, with tinnitus. The membrane is

much retracted, dull, opaque. The *prognosis* for hearing in the acute cases is good if the cause is removed or brought to an end; in the chronic cases it should be very guarded. *Treatment* should be in all cases by the improvement of the antecedent condition, which should be most carefully sought for; in addition, the tympanum should be treated by regulated inflations through the Eustachian tube, and in suitable cases by pneumo-massage. Great perseverance is often needed to establish improvement in chronic cases, in which secondary changes in the tympanum have become established.

**Chronic suppurative otitis media,** unless tuberculous, has always had its beginnings in an acute otitis. True chronic middle-ear suppuration must be clearly distinguished from those cases of chronic muco-purulent catarrh of the tympanum which are so common in chronic infective conditions of the post-nasal space, especially in adenoids. A very large proportion of all cases results from scarlet fever or measles, and originates in childhood. The history in chronic cases is often very defective, the memory of the early stages being lost. In other cases there have been more or less prolonged periods of freedom from discharge, in which circumstances the history is very apt to be begun at the last recurrence. The commencement of a chronic middle-ear suppuration in adult life is comparatively rare. Chronic suppurative otitis media is a disease the importance of which as a menace to health and life is still imperfectly comprehended by the general public; the presence of a middle-ear discharge carries with it a risk which is comparable to that of an uncontrolled hernia: at any time it may suddenly put its possessor's life in the gravest jeopardy by the extension of infective processes within the cranium.

FIG. 166.—Result of scarlatinal suppuration, now exhausted and healed. Large loss of the posterior half of membrana tympani, exposing the scarred inner tympanic wall, the anterior crus of the incus, head of stapes, and stapedius tendon. The surviving parts of the membrane were white and opaque from interstitial calcification. (From life.)

The *otoscopic appearances* vary widely, according to the position and extent of the perforation and the condition of the tympanic space. Small perforations are apt to lie anteriorly, those of larger size below or behind the handle of the malleus; not infrequently almost the whole of the membrane has undergone destruction. In such cases the handle of the malleus may remain or may have disappeared, and the inner tympanic wall is widely exposed. Remaining portions of the membrane may appear normal, may be thickened, or calcified (see Fig. 166). Adhesions between the handle of the malleus or the membrane and the inner wall of the tympanum are frequent. The lower part of the long crus of the incus, the head of the stapes, and the tendon of the stapedius muscle may be exposed in the postero-superior part of the tympanum. When the inner wall is exposed it may be possible to recognise the vessels on the promontory and the niche of the fossula rotunda. When the inner wall of the tympanum is secreting freely it is impossible to identify these anatomical points; under these circumstances it appears as a pink or red surface, covered with swollen, sometimes granulating, mucous membrane; or the view may be entirely blocked by polypi springing from the interior of the tympanic space. Occasionally the cartilaginous meatus has undergone stenosis so that no view of the fundus can be obtained; or the cavity of the tympanum may be choked

with epidermic masses, a condition accompanied in many cases by cholesteatoma of the attic or antrum.

*Hearing* in chronic suppurations varies astonishingly in different cases, and often bears no relation to the amount of apparent damage. It frequently undergoes great variation with changes in the condition of the ear. Unless secondary changes have taken place in the labyrinth, the deafness is of middle-ear type. Hearing is often almost perfect in cases of chronic attic suppuration, with perforation limited to the membrana flaccida.

In many cases of chronic suppuration in the middle ear there is no complaint of anything except the presence of discharge and of more or less deafness. In others, however, symptoms arise which must never be neglected, as they indicate the approach or actual presence of grave complications, and call for immediate operative treatment. Chief among these are headache, vertigo, pain in the ear or behind the ear or in the interior of the head, elevations of temperature, and especially the occurrence of rigors. In many cases of chronic otitis media there is a significant anæmia, lassitude, and general depression, pointing to the continued absorption of poisons from the ear or through the alimentary tract from pus swallowed after draining into the pharynx through the Eustachian tube.

The *diagnosis* rests on the discovery of the issue of pus from the middle ear through a perforation seen or discovered by the auscultatory tube. In chronic suppurations it is rare for the pus to be mixed with mucus; it is generally thin, smelly, and contains masses of cheesy material consisting of aggregations of micro-organisms and dead squamous cells; in many cases there is an entire absence of pus cells in the discharge.

*Prognosis.*—Many cases of chronic suppurative otitis media recover and remain well for long periods under careful treatment. In those which fail to react favourably to treatment there is present some cause for the persistence of the discharge. Such causes must be carefully sought for. They may be continued septic condition of the external meatus, caries of the ossicles, chronic antral suppuration, cholesteatoma, or infection of the bony walls of the tympanum, including the capsule of the labyrinth. The correct treatment of the case must rest on the diagnosis so made. Owing to the risks which such conditions occasion, obstinate cases of chronic suppuration should be treated surgically.

*Treatment.*—The *routine treatment* of cases of chronic suppuration may be summarised in the words, surgical cleanliness. The ear should be thoroughly syringed at least morning and evening with a warm lotion; the composition of the lotion is of far less moment than is the effectiveness of the mechanical cleansing; for cases in which the discharge is not copious and is inoffensive, a solution of sod. bicarb. (gr. xv. to the ounce), or of boric acid (gr. x. to the ounce), is quite adequate; in the majority of cases better results are gained by the use of 1 in 4,000 biniodide of mercury lotion. When there are epithelial masses in the tympanum or very fœtid discharge, a lotion of peroxide of hydrogen, 10 to 20 vol. strength, proves very effective in removing the masses and getting rid of the offensive smell. Carbolic acid, lysol, or formalin have been advocated at various times, but seem to possess no special advantages. *All lotions used should be at body temperature*, as very violent and distressing vertigo may be occasioned by the use of fluids either too cold or too hot. After syringing, the meatus should be dried and powdered with boric acid. Some cases do particularly well on a routine of lightly packing the meatus with gauze after syringing and drying. It is rare for the perforation to close after the cessation of discharge in a case of chronic suppuration. *Granulation*

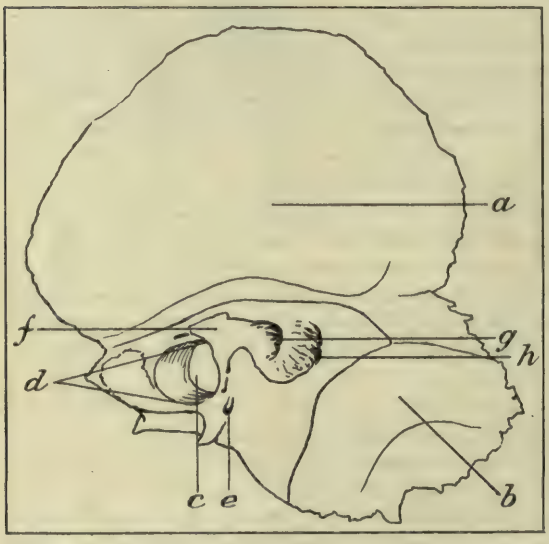



FIG. 167.—Outer part of a right temporal bone (immature), after vertical section at the level of the tympanic ring, viewed from within, illustrating the relations of the middle and posterior cranial fossæ to the cavities of the ear. *a*. Inner surface of squama. *b*. Sigmoid groove in posterior fossa. *c*. External auditory meatus. *d*. Attachment of membrana tympani, upper line pointing to notch of Rivinus. *e*. Aqueduct of Fallopius cut across. *f*. Attic, or epitympanic recess. *g*. Mastoid antrum. *h*. Commencing mastoid cells. (From a specimen of the author's.)

*masses* in the tympanum often speedily disappear under improved conditions; when persistent they should be destroyed by the application of chromic acid in saturated solution.

**Tuberculous disease** of the ear occurs in children and adults. In children it may be subacute or chronic, and may be primarily a disease of the mucosa of the tympanum or in the bony tissue of the base of the petrous. It leads to great destruction of the tympanic structures and not infrequently of the labyrinth. Many cases die of tuberculous meningitis. The local prognosis is good under energetic surgical treatment, but many of the children die within a few years either of disseminated tuberculosis or of tuberculous meningitis.

In adults tuberculous disease is usually a late complication of phthisis. Discharge commences painlessly, preceded by a period in which the membrane is swollen and pink, and the tympanum is filled up by the infiltrated mucosa. The perforations may at first be multiple, but soon coalesce. The disease is progressive, and as a rule it is not wise to attempt surgical treatment, but to confine oneself to maintaining asepsis.

**Polypi** spring in almost all cases from the inner tympanic wall, rarely from the surface of an ossicle or from exposed dura mater, probably in no case

from the outer surface of the membrana tympani. They do not disappear spontaneously, and their presence is certain to perpetuate discharge. They appear as rounded, generally pale, masses lying in the meatus, of soft consistence, not bleeding readily on manipulation with a probe, which can be passed freely all round their outer part. When removed they are seen to be pear-shaped, with a thin stalk of attachment to their point of growth. A polypus is always accompanied by discharge, to the free escape of which it may offer an obstacle. Histologically aural polypi consist of swollen fibrillary tissue, more or less infiltrated with small round cells, and covered by a prolongation of the tympanic mucosa, which in the exposed part may have undergone metaplasia and become squamous.

The *prognosis* in most cases of polypus is favourable if the polypus is thoroughly removed and after treatment is persevered with.

FIG. 168.—Vertical section through the external and internal meatus of a left adult temporal bone, seen from in front. *a*. External auditory meatus. *b*. Tympanic cavity. *c*. Entrance from attic to antrum (aditus). *d*. Petro-squamosal suture in roof of aditus. *e*. Eminence of external semicircular canal in inner wall of aditus. *f*. Aqueduct of Fallopius. *g*. First turn of cochlea within the promontory. *h*. Internal auditory meatus. (From a specimen of the author's.)

*Treatment*.—Immediate removal by the snare or by polypus forceps. Removal should be as complete as possible, and the remains should be destroyed by the application of a saturated solution of chromic acid. Routine treatment must be maintained until the cessation of all discharge.

**Chronic epitympanic suppuration** (*attic disease*).—The epitympanic space or attic is that part of the tympanum which lies above the short process of the malleus and chiefly above the limits of the membrana tympani; it is largely isolated from the main part of the tympanic space by the bodies of the malleus and incus, and may be completely cut off by swelling of the mucosa. An isolated chronic suppuration of this part of the middle ear communicates with the exterior through a perforation of Shrapnell's membrane, and is apt to prove extremely obstinate to treatment, owing to the presence of caries of an ossicle or of the joint between the malleus and incus, or of cholesteatoma. Hearing is in many cases almost perfect, and the

surgeon will feel a corresponding reluctance to the execution of a radical operation in these cases. Careful and prolonged treatment by syringing out the attic through the perforation by means of a special small syringe should be tried before any operative measures are embarked upon, and wherever possible the tympanic structures should be preserved.

**Chronic antral suppuration** may be credited with the causation of continued discharge in those cases in which the tympanum is freely open and in which there is no evidence of active disease in this part. It may be due to a simple passive suppuration in the badly drained cavity of the antrum, which can only be adequately treated after it has been laid open by operation, to the presence of caries in the walls of the antrum, or to the presence of a cholesteatoma. In all these cases the proper treatment is by the radical operation.

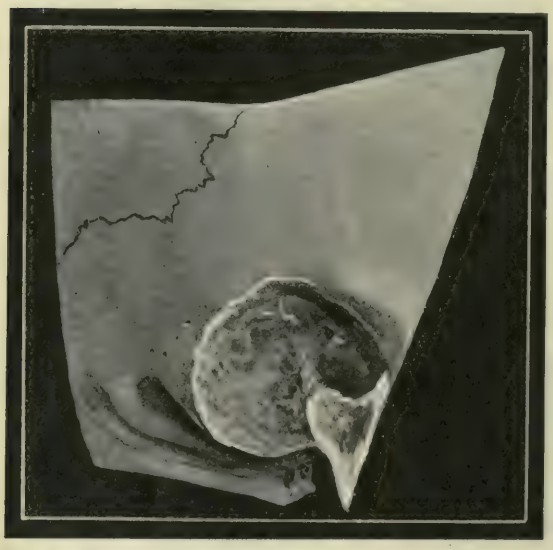


FIG. 169.—Part of a right temporal bone, on which the radical operation has been performed. Tympanum, attic, aditus, antrum, and mastoid cells have been thrown into a single cavity; the tympanic contents have been removed and the posterior wall of the bony meatus has been cut away. (From a preparation of the author's.)

**Cholesteatoma.**—When a chronic perforation exists with continued discharge, the squamous epithelium of the outer surface of the membrana tympani or meatus is apt to extend round the edges of the opening and displace the more delicate cells of the mucous surface. As a result there is an accumulation of cast-off squames within the tympanum, attic and antrum; these become tightly packed together so as to form a solid laminated mass which may break up into pearly layers when removed. Such a mass is known as a cholesteatoma. It forms a favourable nidus for the multiplication of organisms, and is hence one of the most important of the conditions which keep up a discharge. In addition, a cholesteatoma possesses a remarkable power of causing the absorption of bone, so that large cavities may be formed in the interior of the temporal bone, the dura mater may be widely exposed, and the interior of the labyrinth may be opened. The condition may be diagnosed by the removal of masses of laminated epithelium from the middle ear, but many cases only reveal their nature when the mastoid antrum is opened by operation. When diagnosed, cases of cholesteatoma should be submitted to the radical operation without delay.

**The operative treatment of chronic suppurative otitis media.**—While various minor operations are sometimes carried out by aural specialists with a view of sparing as far as possible the capacity for hearing, the only procedure which need be considered here is the radical mastoid operation. Besides its importance in the treatment of chronic suppurations, this operation forms a necessary preliminary to the satisfactory treatment of the intracranial

complications of suppurative otitis media. The principle of the radical operation is the complete opening of the middle ear, attic, and antrum into a single cavity, the removal of the remains of the tympanic structures and of all diseased tissues, and the provision of free and permanent drainage for the whole of the cavity so formed. It is open to the surgeon to graft the cavity in suitable cases; by this means the period of healing is shortened.

A curved incision is made through the tissues behind the attachment of the pinna, which is turned forwards; the cartilaginous meatus is detached from the bone posteriorly. By means of the hammer and gouge the bone lying behind the upper part of the posterior meatal wall is removed in successive layers until the antrum is opened. The aditus, or passage connecting the antrum with the attic, is now opened up by the removal of the bone on its outer side and the attic wall is cut away; in this part of the operation special care is needed to avoid injury to the external semicircular canal and the facial nerve. It is not uncommon for the nerve to be exposed by caries

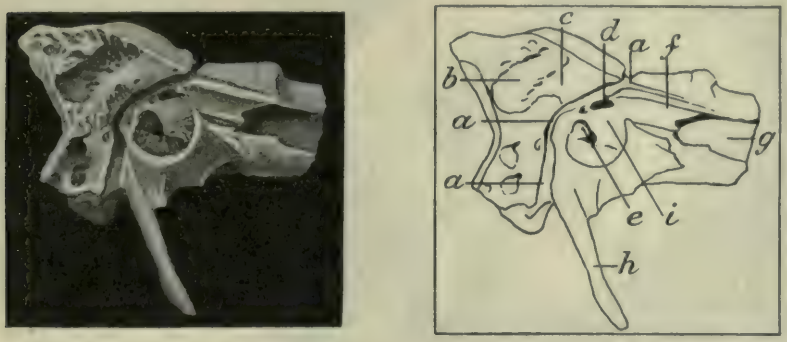



FIG. 170.—Part of a right petrous bone. The squama, mastoid, and tympanic plate have been removed, and the inner wall of the tympanum and antrum exposed. *a*, *a*, *a*. Aqueduct of Fallopius laid open from the internal auditory meatus to the stylomastoid foramen. *b*. Cavity of mastoid antrum. *c*. Eminence of external semicircular canal. *d*. Oval window. *e*. Recess of round window. *f*. Eustachian tube. *g*. Carotid canal. *h*. Styloid process. *i*. Promontory. (From a preparation of the author's.)

or defect of the bony wall of the aqueduct of Fallopius in the tympanic part of its course, and the greatest care must always be exercised in curetting granulations in the upper and posterior part of the tympanum. The remains of the membrane and ossicles are removed by a curette. The posterior wall of the bony meatus is now cut away in such a way as to allow of natural drainage forwards of all parts of the bony cavity; in this removal of bone care and knowledge of the anatomy of the region are necessary to avoid disaster to the facial nerve. The cartilaginous part of the external meatus is now remodelled and enlarged by the formation of a flap from its floor and posterior wall. This is cut by entering a tenotome along the meatus and cutting outwards along the floor of the meatus to the junction of the meatus with the pinna; the knife is then carried backwards and upwards just outside the margin of the concha to the level of the meatal roof. By this means a flap is formed consisting of the floor and posterior wall of the cartilaginous meatus, which hinges along the junction of the posterior wall with the roof. From its deep surface the cartilage and fibrous tissues are dissected so as to leave a skin flap, which may be fixed to the edge of the temporal fascia and

the deep surface of the tissues of the pinna, or may be left to assume its natural position when the cavity is packed. If grafting is carried out a very thorough removal of mucous membrane must be made in the tympanum and antrum; Thiersch grafts are then applied to the whole of the surface of the operation cavity, either immediately, or after a period as in Ballance's original procedure. In either case the cavity is filled with gauze plugging, which should be carefully and evenly introduced.

The first dressing is carried out after three days, by which time grafts, if they have been used, are firmly adherent. Subsequent treatment must be by irrigation and packing until the whole of the cavity is soundly healed, a process which takes about two months on the average when grafting is not carried out. The results obtained are highly satisfactory, suppuration being arrested, while in many cases hearing is sufficiently good, even after a bilateral radical operation, for ordinary speech to be well understood.

FIG. 171.—Part of a right temporal bone, illustrating the extent and continuity of the air-chambers of the ear. The roof and posterior wall of the external auditory meatus and the outer shell of the mastoid process have been removed, and the septa between the mastoid cells have been broken down, exhibiting a continuous cavity reaching from the tympanic opening of the Eustachian tube to the tip of the mastoid, the mastoid and tympanic parts communicating through the aditus above. (From an anatomical preparation of the author's.)

### The Extensions of Infective Processes from the Middle Ear and Antrum.

Infection may spread from these areas—

1. To the mastoid cells and diploe, producing *acute suppurative mastoiditis.*
2. To the inner surface of the cranium, producing *extradural abscess.*
3. To the lateral sinus, producing *sinus thrombosis and pyæmia.*
4. To the brain, producing *encephalitis and brain abscess.*
5. To the labyrinth, producing *infective labyrinthitis.*
6. To the lepto-meninges, producing *leptomeningitis.*

1. **Acute suppurative mastoiditis** may occur in the course of either acute or chronic suppurative otitis media; it is, however, far more common in the acute and recent form, the commonest period of occurrence being the third week of suppuration. Owing to the non-existence of the mastoid cells in early childhood, typical acute mastoiditis is not seen before the fourth year. Prior to this age acute antral suppuration may take place with the development of a mastoid abscess. Owing to the wide distribution of the mastoid cells in adults, the infected area within the bone may be a very extensive one.

The symptoms of suppurative mastoiditis are pain and tenderness over the mastoid, with, in the later stages, the appearance of an œdematous

swelling, and finally of fluctuation behind the ear. The temperature is often only slightly raised. An important early sign is the presence of swelling in the deeper part of the posterior wall of the bony meatus. When a superficial abscess is formed, it is subperiosteal in position; it tends to spread upwards and forwards into the temporal fossa superficial to the temporal fascia. Within the mastoid there is much absorption of the bony septa between the cells and also of the inner table of the bone, so that the dura mater of the middle and posterior cranial fossæ is often widely exposed and covered by granulations at the time of operation. The lateral sinus not infrequently forms a part of the boundaries of the abscess cavity. If neglected, the abscess may burst externally, with the formation of a permanent discharging sinus which becomes secondarily infected, and finally may lead to death from secondary septic complications. In many cases, however, before this takes place the patient will have succumbed to earlier complications resulting directly from extension of the disease within the mastoid to the interior of

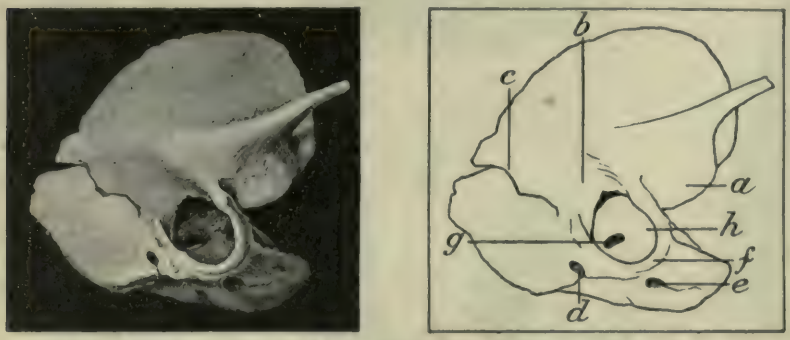



FIG. 172.—Right temporal bone of an infant, seen from the outer side, to illustrate the peculiar anatomy of the bone in this stage. *a*. Shallow glenoid fossa. *b*. Roof of bony meatus formed by squamous, and extending to form the outer wall of the antrum. *c*. Petro-squamosal fissure. *d*. Stylomastoid foramen. Note its exposed position and absence of mastoid process. *e*. Opening of carotid canal. *f*. Tympanic ring, incomplete above; this will later grow out to form the floor and sides of the bony external meatus. *g*. Oval window. *h*. Tympanic opening of Eustachian tube. (From a preparation of the author's.)

the cranium. An early operation is urgent as soon as the diagnosis of the condition is reasonably sure.

When large and thin-walled cells exist at the tip of the mastoid process, their involvement in suppurative mastoiditis may lead to the perforation of pus through the thin inner shell of bone which separates their cavity from the digastric fossa and the deep tissues of the neck. This "*Bezold's perforation*," by leading to the relief of tension within the mastoid and the formation of an abscess in the neck, may cause the overlooking of the true nature of the case. The pus tends to track downwards and forwards along the digastric muscle, so that an abscess forms against the lateral aspect of the pharynx—more rarely it passes down along the line of the sterno-mastoid muscle, and cases are recorded in which counter-opening has been made at the level of the clavicle. The special symptoms of Bezold's perforation are swelling, tenderness and induration under the upper part of the sterno-mastoid, and the carriage of the head towards the side affected in order to relax the muscle. If the diagnosis is correctly made before the condition is very far advanced it is rarely necessary to make a counter-opening in the neck. The perforation

in the apex of the mastoid into the neck should be freely enlarged after a Schwartze's operation (*vide infra*) has been carried out. The cases do well.

Necrosis of the mastoid in acute mastoiditis is uncommon except in those cases which result from the acute otitis media of scarlet fever.

Cases of acute suppuration in the mastoid secondary to recent otitis media should be treated by *Schwartze's operation*, the aim of which is completely to open all cells and remove all infected tissue within the mastoid while leaving untouched the tympanic structures, which in these cases are quite capable of rapid recovery when drainage is established. The operation is carried out through an incision similar to that for the radical operation. It is crescentic and lies behind the attachment of the pinna, following it at a distance of about half an inch ; it must extend downwards as far as the tip of the mastoid process. The soft meatus is not detached from the bone, and the posterior wall of the bony meatus is carefully preserved. The operator should make sure that the antrum is really opened by passing a bent probe gently forwards through the aditus towards the attic of the tympanum, care being taken not to dislocate the incus. The cavity finally created is often very large ; it is best to drain it by a tube fixed in the lower end of the wound, in which case the wound may be sutured ; but if preferred the wound may be left open and the cavity packed until complete cicatrisation has taken place.

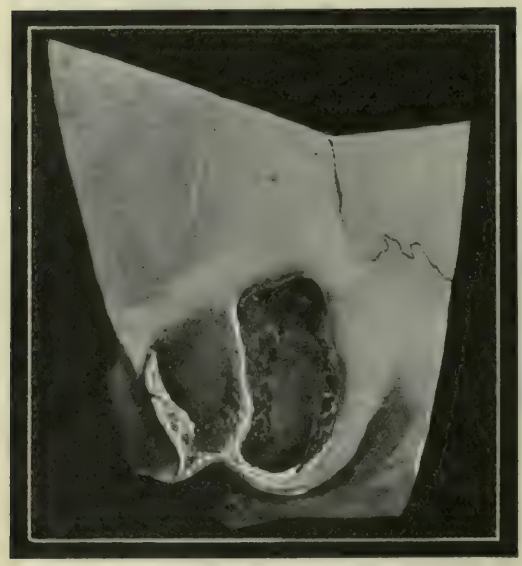


FIG. 173.—Part of a left temporal bone, on which the Schwartze operation has been performed. The mastoid region is opened up without interference with the external auditory meatus or tympanum. (From a preparation of the author's.)

In cases of acute mastoiditis complicating a chronic suppurative otitis media, it is best to perform a radical operation at once, as in the majority of such cases the tympanum is incapable of recovery.

2. **Extradural abscess** secondary to otitis media may be either in the middle cranial fossa, above the tegmen tympani, or in the posterior fossa, along the lateral sulcus. The abscess of the posterior fossa is by far the more common, and may complicate either recent or chronic middle-ear disease. The symptoms of extradural abscess are as a rule very obscure ; headache is the most prominent ; elevation of temperature may be present. If the accumulation of pus is very large, there may be symptoms of intracranial pressure with papillœdema. The majority of otitic abscesses outside the dura mater are discovered in the course of operations undertaken for threatening symptoms in cases of otitis media, without any definite diagnosis of extradural abscess being made previously.

*Treatment.*—The extradural abscess of otitic origin should always be treated

as an extension of the disease of the ear, by an extension of the operation on the antecedent condition. The whole of the bone which forms the outer wall of the abscess should be cut away, so as to afford free drainage. In the majority of cases the operation may be terminated on the lines of an ordinary radical operation or of a Schwartze's operation, as the case may be; but where the abscess is unusually large it is advisable to keep the incision open and drain through it until the safety of the patient is assured, when the wound may be secondarily sutured.

3. **Thrombosis of the lateral sinus** is one of the most formidable and fatal of intracranial diseases. With rare exceptions it is a complication of middle-

FIG. 174.—Caries and necrosis of the right temporal bone, due to chronic suppurative otitis media. Squamous, petrous, and mastoid portions are all attacked. (From a specimen of the author's.)

ear suppuration, generally in the chronic stage but occasionally in recent infections. While in rare instances the process may end in spontaneous cure by limitation and abscess formation, its natural ending is by septicæmia and death. Infection of the sinus is nearly always by the streptococcus pyogenes, followed by a large variety of pathogenic and non-pathogenic organisms from the ear.

The outer wall of the sinus shares with the rest of the dura mater a high degree of resistance to the penetration of organisms, and clinical evidence makes it probable that direct passage of infection through the wall of the sinus is the exception. Entrance to the blood-stream probably takes place in the substance of the bone, and cocci pass from the intraosseous sinuses

along the mastoid veins to the interior of the lateral sinus, producing thrombosis as they go. Thrombosis of the sinus is primarily a protective effect, localising the infection. In cases in which thrombotic occlusion fails an acute general blood infection may occur immediately. Usually, however, this is delayed for from two days to a week, when the clot softens and particles become detached and carried into the general circulation. The commonest place of lodgment is in the lung near its pleural surface, but a general blood infection is in all cases present when pyæmic foci exist. Death takes place either through septicæmia, pulmonary abscess and gangrene, or by local spread to other venous sinuses and to the meningeal veins, leading to a purulent lepto-meningitis. Thrombosis may spread downwards along the internal jugular vein, progressing even to its junction with the subclavian vein. In itself this involvement of the jugular influences the course of the disease only slightly. On the other hand, extension forwards along the petrosal sinuses to the cavernous sinus, and backwards to the superior longitudinal sinus and the opposite lateral sinus, is almost necessarily fatal. By the direct passage of infection through the necrotic inner wall of the sinus to the cerebellum, an abscess may be caused in the outer part of the lateral cerebellar lobe.

*Symptoms and course.*—Occurring generally in the course of a chronic suppurative otitis media, the onset of lateral sinus thrombosis is frequently foreshadowed by a few days of malaise, headache, and local pain, with an irregular temperature. Actual thrombosis is generally signalised by a rigor with a temperature of 103 degrees or higher, followed by a period of several days in which the temperature is more or less constantly elevated, the chart at this stage rather resembling that of pneumonia. With the commencement of disintegration of the thrombus the temperature becomes strikingly irregular, with recurring rigors, which may occur in orderly succession or may show no regularity. This type of temperature chart is maintained until death in unoperated cases, the oscillations being often of an extraordinarily sudden type, so that a rise and fall through 8 or 10 degrees may take place in a few hours. The patient's general condition rapidly gets worse. The rigors are followed by heavy sweats. Strength wanes, the colour becomes earthy, and the pulse weak and rapid, the whole picture being one of intense intoxication.

*Local condition.*—There is little to be learned by otoscopy beyond the existence of a chronic purulent discharge. This may so far decrease in quantity with the rise of temperature as no longer to appear externally. Its existence may be denied by the patient or his friends. While superficial œdema or abscess may be present in the mastoid region, it is by no means the rule. More commonly there is found a deep tenderness in the mastoid region, and especially along the posterior border of the process; this may extend backwards in a narrow line along the course of the horizontal part of the lateral sinus for a variable distance. It is often said that the thrombosed jugular vein may be felt in the neck. While thrombosis may extend far down the vein, it is only in exceptional cases that the vein itself can be felt, the clot being very soft and the vein overlaid by greatly-enlarged lymphatic glands, while both vein and glands are obscured by surrounding lymphangitic swelling. The whole forms an elongated, very tender swelling along the course of the upper part of the internal jugular vein. Rarely an abscess may form in this region.

The *diagnosis* is only made certain by operation. It may be made with sufficient assurance to lead to operation on the strength of the following points:—Presence of purulent middle-ear discharge; septic aspect and chart,

with one or more rigors; tenderness behind the ear, and especially along the jugular; swelling of the upper deep cervical glands; headache. The condition is of such gravity that a fully-developed picture should never be waited for. In late cases the clinical aspect may be modified by the presence of meningitis or of pulmonary complications. There is one clinical type in lateral sinus thrombosis which deserves special notice owing to the ease with which it may lead to a fatally wrong diagnosis. It has been described as the typhoid type, and closely resembles this disease. The patient has a more continued fever than is usual in sinus thrombosis, headache, often some bronchitis; there are liquid offensive stools, swollen abdomen, enlarged

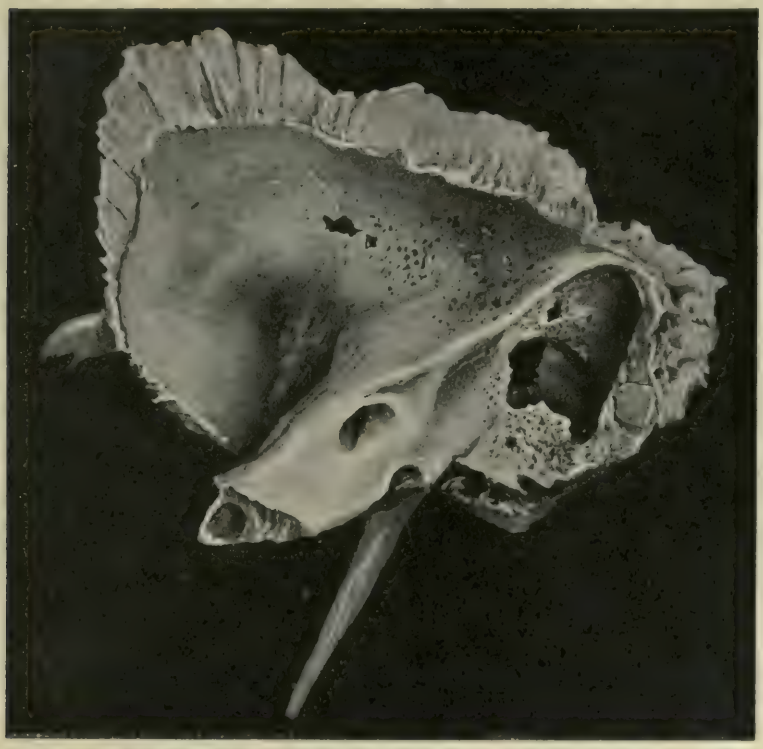


FIG. 175.—Infection has spread to both middle and posterior fossæ, in both of which there has been extradural suppuration. Death was probably due to lateral sinus thrombosis. (Inner aspect of same specimen as Fig. 174.)

spleen, and in some cases a septic abdominal rash. The negative Widal and a high leucocytosis should lead to the examination of the ears if this has been omitted.

*Prognosis* is necessarily grave. Of cases operated on within five days of the onset of thrombosis about 70 per cent. recover. Pulmonary infection adds very greatly to the dangers, but is not necessarily fatal. Meningitis is invariably fatal in these cases. The possibility of a cerebellar or cerebral abscess should be remembered as a complication.

*Treatment.*—The best treatment is anticipatory. A free radical mastoid operation should be carried out on the first threatenings of intracranial complication. In all such cases the descending part of the lateral sinus should

be freely exposed and inspected. If its wall is found to be resistent or necrotic there is no doubt of the condition. When the wall of the sinus is found to be granulating its interior will generally be unaffected.

The objects of the operation for lateral sinus thrombosis are the removal of the primary infective focus in the ear and mastoid, the interruption of the channels by which sepsis is being conveyed to the general circulation, and the complete removal of the infective thrombus and drainage of the lumen of the sinus. This calls for a radical mastoid operation, the opening, emptying and obliteration of the diseased part of the sinus and jugular, and the plugging of the posterior end of the opened sinus and interruption of the internal jugular vein in the neck. When the diagnosis of thrombosis is reasonably sure, it is probably best to carry out the operation on the vein in the neck first. The vein is exposed by an incision along the anterior border of the sterno-mastoid, starting at the level of the angle of the jaw and ending at the level of the cricoid cartilage, or lower in cases of extensive thrombosis. The vein will be found to be overlaid by swollen adherent glands, which should be removed. As a rule it may conveniently be tied and divided at the level of the upper border of the thyroid cartilage. The vein is then dissected up as near the base of the skull as possible, tied off, and the end allowed to retract into the upper angle of the wound. The incision is closed except at the lower end, through which a tube is brought out, and a collodion dressing is applied. A radical mastoid operation is now carried out if this has not already been done, and the descending part of the sinus is exposed and followed to the limit of thrombosis backwards and to the lower bend on the jugular process below. Gauze plugging is packed between the sinus and the bone at either end ; the sinus is laid open and the clot removed. The wound is left entirely open for the time, and later, if the case goes well, is closed by secondary suture. When clotting has extended into the jugular bulb this must be cleared out from above with a curette.

Cultures should in all cases be made from the distal parts of the clot, as there is a better chance of getting a growth uncontaminated by secondary organisms in this way. The writer makes a practice of giving a sensitised streptococcal vaccine empirically forthwith, but it is well to have an autogenous vaccine prepared with all speed.

4. **Encephalitis and brain abscess.**—Infection may spread from the middle ear, passing upwards to the temporo-sphenoidal lobe, or from the mastoid, passing backwards to the cerebellum. In either situation the abscess, when due to direct spread, is invariably in continuity with the original focus of infection across an area of meningeal adhesion, though subcortical elsewhere. Occasionally abscess is due to pyæmic infection. In this case its position is fortuitous, and the commonest place is the interior of the frontal lobe.

Otitic abscess of the brain is almost always a complication of chronic middle-ear suppuration. Abscess the result of recent otitis is exceedingly rare. While occasionally an exciting cause may be found in a blow or some operative traumatism, the determining condition of the penetration of infection cannot usually be identified. The course of events is the spread of infection to the dura mater, adhesion of the dura to the brain, and passage of infection along a thrombosed vessel or a perivascular sheath through the cortex to the relatively non-vascular white matter. Here an area of necrosis is formed, which may continue to spread diffusely or become localised by an inflammatory wall and form a true abscess. On the whole, well-limited abscesses of the brain are the exception, but cases occur in which a thick, tough abscess wall is formed.

The bacteriology of the acute ill-defined abscess is usually a sample of that of the chronic otitis media. The old chronic abscess is often sterile by ordinary culture methods. The fluid from an otitic abscess of the brain is exceedingly offensive, greenish or brownish in colour, and contains as its main contents micro-organisms and fragments of broken-down brain tissue. The whole process is rather a necrosing encephalitis than a true abscess formation.

*Course, signs, and symptoms.*—Otitic encephalitis may vary widely in its course, some cases running quickly to the end by continued spread of the infective process, while others develop insidiously and progress slowly. In general, the more rapid the process the more marked will be the septic aspect of the case, in extreme instances closely resembling an acute otitic meningitis, while the more slow the development the more clearly will the compressive side of the condition be emphasised. Few diagnoses present more difficulties than that of otitic abscess, and it is often necessary to conduct an exploration of the brain on suspicion. In otitic brain abscess the classical triad of signs—headache, vomiting, and papillœdema—proves a broken reed to lean on. Headache is common to all the intracranial complications; vomiting may take place only occasionally, and only after food or in the early stage of the condition; while papillœdema is more frequently absent than present in the obscure cases in which a trustworthy guide would be invaluable. When present it is, of course, of the greatest value, but even so furnishes no conclusive evidence of the presence of an abscess. In the early stages the differential diagnosis from meningitis turns largely on the result of lumbar puncture. There is fever, of variable degree, intense headache, and probably vomiting. With these there may be already a suspicious torpor or mental obscuration or failure of the faculty of continued attention, so that questions are badly answered. Localising signs, rare in temporo-sphenoidal abscess, are hardly ever present in the early stage. As compression deepens the picture becomes clearer. The key to the general diagnosis, apart from questions of locality, lies in the pulse, temperature, respiration ratio. The pulse is, relatively to the temperature, a slow one; there may, for example, be a pulse in an adult of seventy with a temperature of 101 degrees. Its quality also tends to be peculiar: it feels slower than it counts in many cases; is soft, full, and often manifestly dicrotic, with a slowly-rising wave of pressure. It has been well described as a "lazy" pulse. The temperature tends steadily to fall as compression deepens, and may go down as low as 96 degrees. The combination of a subnormal temperature with an abnormally slow pulse is very suspicious. Respiration also becomes slow, shallow, and intermittent in the later stages, especially in cerebellar cases. True Cheyne Stokes respiration is rarely seen, but a modified form of it is common in the terminal phase. The breathing slowly sinks to nothing, there is an apnœic pause, and then a deep sighing inspiration, from which again the depth of inspiration gradually falls away. Such a condition is a mark of extreme urgency and approaching death if relief is not prompt. If the surgeon is to save his case he cannot afford to wait for the full development of these features.

Lumbar puncture yields a fluid under raised tension, clear or slightly turbid, but, unless there is a complicating meningitis, free from organisms. It has not lost its alkalinity or its reducing power.

**Differential diagnosis between temporo-sphenoidal and cerebellar abscess.**—In temporo-sphenoidal abscess the brunt of the compression falls on the hemispheres; in cerebellar abscess, on the medulla. Thus we may anticipate that in temporo-sphenoidal abscesses consciousness and attention

and voluntary motor power will be affected before the vital processes are dangerously depressed; in cerebellar cases it will be on these vital centres that the pressure will first tell, while the upper centres are shielded to a great extent by the tentorium. Later, when compression deepens, intelligence and vital process alike suffer.

Genuine paralytic symptoms are rare in abscess of the brain of otitic origin; they occur occasionally in the more chronic cases, and the paralysis is a spreading one, involving the face, arm, and leg of the opposite side in succession. Twitchings in the face and arm may be due to encephalitis, but generally mean the presence of a meningo-encephalitis and not an abscess. The paralyses are due to pressure on the anterior part of the internal capsule and the corona radiata, and are restricted to temporo-sphenoidal cases.

In cerebellar abscess the pulse and respiration are affected early, while consciousness is almost normal in many cases. By the direct pressure on the pyramids the reflexes are often greatly exaggerated, the knee-jerks even being sometimes transformed to a definite clonus and ankle clonus being common. The plantar reflex is normal, or may be doubtfully extensor if there is much meningeal effusion. Nystagmus is a very valuable sign when it is present, but is often looked for in vain. The nystagmus of the abscess of the lateral lobe of the cerebellum is a coarse movement, horizontal, slow and swinging. It must be carefully differentiated from that of labyrinth destruction, which is more rapid, finer, has a rotatory element in its direction, and is towards the opposite side to the affected ear. It must be borne in mind that both lesions may be present, and that their appropriate nystagmus may be manifested in succession, the cerebellar type superseding the labyrinthine. When the patient is sufficiently conscious, there may be found a characteristic ataxia and loss of the power of carrying out contrasted movements with the two arms (dysdiadokokinesis).

*Treatment.*—In encephalitis and suppuration of the brain operation holds out the only hope of escape for the patient. In those cases which arise from middle-ear suppuration the route through the region of the radical mastoid operation is greatly to be preferred. It possesses the merits of simplicity, quickness, and direct access. After a roomy radical operation has been carried out the removal of the tegmen and the root of the squama quickly exposes an area of dura mater, through which infection has in all probability passed in temporo-sphenoidal cases, and through which exploration of the appropriate region of the brain is easily carried out. If a sinus is found leading into the brain it is carefully dilated, and after the flow of pus has ceased a tube is inserted. If no definite lead is obtained it is probably best to explore the outer surface of the dura mater in the cerebellar region before incising. The mastoid cavity is then disinfected as far as possible (the writer uses pure izal for the purpose), and the dura mater is incised with a sharp scalpel, any visible vessels on the dura mater being avoided. The brain bulges immediately through the incision. With any suitable semi-sharp instrument the brain is now explored; the explorer is passed first directly upwards for three-quarters of an inch, then in succession forwards, backwards and inwards if no pus is found.

When the abscess cavity is entered the greatest care must be taken that its position is not lost. The exploring instrument must be held in position until a suitable drainage has been introduced along the side of the instrument. The drainage of abscesses of the brain presents great difficulties owing to the immediate collapse of the walls of the cavity and their semi-fluid nature. Lateral holes in tubes are worse than useless, as they become immediately

choked by brain matter, and these plugs are torn away every time the tube is turned or removed, thus exposing fresh surfaces of brain to infection. A rubber tube of large calibre, or a couple of tubes sewn side by side, without lateral holes, seems the best form of drain. Once the tube is introduced it should if possible be left undisturbed for at least a week until a definite wall surrounds the tube track. It may then be withdrawn and shortened very gradually. Haste in the withdrawal of drainage is much to be avoided, and early disturbance of the tube is responsible for many disasters.

To reach the cerebellar dura mater the cavity of the mastoid operation must be extended backwards. Bone is removed until the lateral sinus comes into view. The cerebellum may be reached either to the outer or inner side of this, and the choice must be determined to some extent by the difficulties of the particular case. When the sinus lies far forwards and the space to its inner side is very cramped, the dura mater on its outer side may be exposed and incised in a vertical direction, but whenever possible it is better to keep closely along the posterior aspect of the petrous bone until an exposure of the dura mater is obtained on the inner side of the sinus sufficient to allow of an incision between the sinus and the internal auditory meatus. By this latter route the line of infection is followed, and the abscess is reached with less disturbance of the cerebellum and with better chances of finding it if small. Drainage should be managed on the lines already described.

Where owing to the diffuse and spreading character of the encephalitis the symptoms of pressure and sepsis are not relieved by simple drainage, the prognosis, already very grave, becomes extremely bad. In the writer's experience the only successes in such cases have come from very bold treatment. A wide removal of the bone and dura mater is made over the infected region of the brain, and brain is then removed over a corresponding area until the infected white matter is widely exposed. Two out of three cases—all under desperate conditions—so treated have recovered, one temporo-sphenoidal, the other cerebellar, and in neither case, in spite of the sacrifice of large amounts of brain, has there appeared to be any serious permanent impairment of function.

5. **Infective labyrinthitis.**—Infection may spread to the interior of the labyrinth either through an erosion of the bony labyrinthine capsule or through a defect in the structures closing the round and oval windows, *i.e.*, through the membrana secundaria tympani or through the footplate of the stapes and the annular ligament. Owing to the immediate access to the large space of the vestibule when entrance is made through the windows, such cases are generally of the type of a diffuse acute infection of the whole of the labyrinthine chambers. On the other hand, when the point of entrance is through an opening in the external semicircular canal, the area of infection is often limited to its immediate neighbourhood, the canal becoming obliterated by inflammatory tissue, and the infection thus shut off from the general cavity of the labyrinth. Of antecedent factors leading to the formation of pathological openings in the labyrinth, cholesteatoma is by far the most important. The entrance of infection into the interior of the labyrinth during the course of an acute otitis media is relatively uncommon, the majority of such cases being scarlatinal. When it occurs, it is usually through the membrana secundaria of the round window. Labyrinthitis may be either acute or chronic; the acute form is always diffuse; the chronic form may be either diffuse or limited.

The *special symptoms*, vertigo, nystagmus, and, in the acute cases, vomiting, headache, and deep-seated pain, should always be viewed with grave atten-

tion, and such cases should never be dismissed without a thorough investigation by means of the special technique already mentioned. Many cases, however, have passed out of the stage of overt symptoms and are apt to be altogether missed unless great care is taken in their examination. The risks attending the possession of an infected labyrinth are not to be measured by the intensity of the symptoms presented. By the further spread of infection from the labyrinth there are produced many cases both of meningitis and of cerebellar abscess. Probably about half the cerebellar abscesses, and certainly the great majority of meningeal infections, owe their origin to this route. The obviousness of the consequences of the destruction of one labyrinth diminishes with the length of time which elapses from that event, but the risks endured by the patient do not similarly decrease. It is true that the greatest risk for the meninges is during the early period, but the dangers of a chronic labyrinthitis are very real and do not diminish with the further lapse of time.

The *treatment* of infective disease of the labyrinth is by the operative opening and drainage of the vestibule, and if necessary of the cochlea and ampullary part of the external canal. Great care is needed to avoid damage to the facial nerve in these operations, which should never be undertaken without a thorough knowledge of the anatomy of the locality. They have been systematised under the names of Inferior and Double Vestibulotomy.

6. **Otitic meningitis.**—Meningitis may occur as a complication of both acute and chronic otitis media. In the acute otitides of childhood it is not very uncommon, but is excessively rare in this condition in adults. In chronic middle-ear suppurations it may occur at all ages. In acute otitis the route of infection may be either along vascular channels through the dura mater, through the labyrinth and internal auditory meatus, or by the blood-stream; in the chronic middle-ear suppurations the commonest though not the exclusive route is through the labyrinth and internal meatus. In the majority of cases the infection is either streptococcal or pneumococcal.

*Symptoms and diagnosis.*—The symptoms of meningitis are protean and its diagnosis on symptoms often extremely difficult. In a typical case there is headache, rise of temperature, and vomiting. The patient is irritable and later drowsy, but when roused is perfectly intelligent until the late stages, when either intracranial pressure or destruction of cortex has largely abolished consciousness. There may be delirium, but as a rule the patient tends to lie quietly for long periods if left undisturbed, these periods being broken by paroxysms of acute pain in the head, during which he may cry out. A variable squint is often present; other paralyses are rare. Often there is a fine fibrillary movement about the angle of the mouth, and small twitchings of the fingers may be noticed. Definite retraction of the head may be present; more commonly there is stiffness of the posterior muscles of the neck and inability to allow the head to be bowed on the chest. The abdominal reflex is lost with fair constancy; the plantar reflex may be dorsal in character, and flexion at the hip is limited. The knee-jerk may be normal or diminished. The early diagnosis of meningitis is, however, of the greatest importance, and can rarely be made on such grounds as these. Lumbar puncture affords a certain and rapid method of making the diagnosis, and at the same time affords temporary relief to the worst symptoms. The fluid issues under considerable pressure, and is turbid to a varying degree. Microscopically its contents are leucocytes, mainly polymorphonuclear, and bacteria, which may only be found after the fluid has been centrifuged, or even on culture. Chemically

the fluid has lost its alkalinity and may be definitely acid, and has lost its reducing power. These chemical changes are the earliest which we can identify in meningitis, and are sufficient to justify the diagnosis.

*Pathological anatomy.*—While cases of meningitis form a continuous series, they may be grouped roughly under two main types, the serous and purulent or phlegmonous—in common terms, those with thin and thick exudates. Serous meningitis, if the patient survive long enough, may become purulent, but there are cases marked from their commencement by the small volume of exudate and its thick and purulent character. In the purulent type there is much softening and destruction of underlying cortex, and the process may be described as meningo-encephalitis. The serous type kills mainly by pressure, the purulent by sepsis, local and general. Except when infection has reached the meninges through the blood-stream, the process starts in the basal region, and thence spreads with more or less rapidity to the spinal meninges and the upper surface of the cerebellum and forwards by the inter-peduncular space and the Sylvian fissures to the cortex. Here it tends to spread continuously over the whole of the convexity, the pus being often most thickly plastered over the upper part of the hemispheres. Through the apertures in the roof of the fourth ventricle infection reaches this cavity, and spreads thence up the ventricular system through the third to the lateral ventricles. By the resulting internal hydrocephalus pressure is exerted in a way which does not admit of relief by drainage procedures, while the vital centres are directly attacked in the floor of the fourth ventricle.

*Treatment.*—The objects of treatment in infective meningitis are, first and most urgent, the relief of pressure ; second, drainage of the subarachnoid space ; third, the raising if possible of the patient's specific resistance to the invading organism. Relief of pressure may be immediately and as a rule effectively obtained by lumbar puncture. The effect is, however, intermittent and, considered as drainage, quite inadequate. Lumbar puncture should take its place as a measure of diagnosis and of immediate relief until further treatment can be instituted. The urgency of adequate surgical treatment cannot be exaggerated. Subarachnoid drainage may be carried out by three different routes, the translabyrinthine, the occipital, and the lumbar, or by any combination of them.

Translabyrinthine drainage is in its nature a specialist's operation, requiring an accurate and minute knowledge of the anatomy of the ear under surgical conditions. It is specially applicable to cases of meningeal infection through the labyrinth. After the labyrinth has been opened below the facial nerve (inferior vestibulotomy), the inner wall of the vestibule is broken through so that the internal auditory meatus is opened. There is an immediate and copious escape of cerebro-spinal fluid, the meatus opening at its inner end directly into the cisterna pontis, and hence draining the whole of the basal cisterns very effectually. The method has the advantages of opening that region of the meninges which is first infected through the actual route of infection and of adding very little to the duration of the radical mastoid operation, which is a necessary antecedent to any rational treatment of otitic meningitis. Drainage may be effectually kept up by this method for as long as a week.

Occipital drainage has the advantages of a less specialised technique and of the possibility of complete aseptic conditions for the opening of the meninges. In the adult it is in itself an operation of some magnitude. It is conducted through an incision in the middle line posteriorly reaching from the external occipital protuberance to the spine of the axis. The incision is carried through

the periosteum of the occipital bone and is deepened until the posterior arch of the atlas is distinctly felt. A triangular piece of bone based on the posterior margin of the foramen magnum is then removed either by trephine and saw or, as the writer prefers, by mallet and gouge. The dura mater so exposed lies over the depression between the cerebellar lobes posteriorly, which is spanned by the arachnoid and floored by the inferior vermis. The dura mater and underlying arachnoid are incised. Both these methods have the advantages of giving prolonged drainage and absence of brain herniation. In the latter point they are vastly superior to any method of opening the dura mater laterally in the cerebellar fossa.

Lumbar drainage is the simplest but also the least effective method. Its distance from the site of infection is its great weakness. In cases with much fluid exudate it is, however, a valuable addition to either of the higher operations. It is carried out by introducing a trocar and cannula into the lumbar theca, leaving the cannula *in situ* and surrounding it with a large Keith's dressing. Drainage by this method has remained operative for fifteen days. By procedures of effective drainage the patient can be saved from death by compression, and can in many cases be kept alive for a fortnight or more. In isolated early and relatively mild cases recovery will take place. The gap in the treatment of meningitis lies now on the side of immunity. If the patient's power of resistance to an established meningeal infection can be adequately raised, the surgeon can undertake to prolong life sufficiently in most cases for time to be given for this. Unfortunately it is the common experience that no application of either vaccines or sera has any marked effect. The cerebro-spinal fluid is a high dilution of the organic constituents of the plasma, and it seems as though this must explain the difficulty in influencing the growth of organisms in it. If any method of effectually raising the antibacterial content of the cerebro-spinal fluid can be devised, we may look forward to an immediate and very large improvement in the statistics of meningitis.

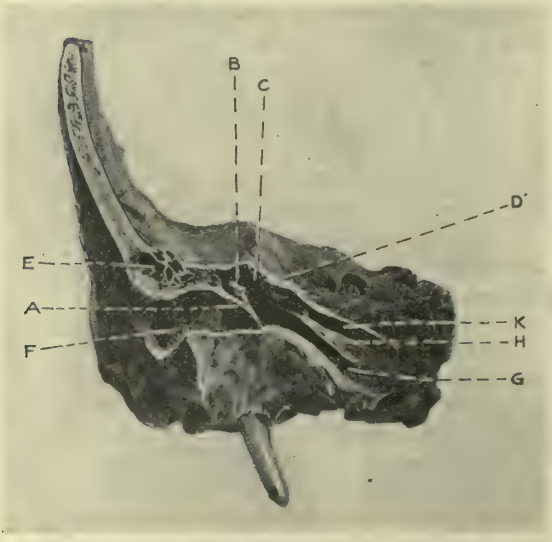



FIG. 176.—Dissection of the right temporal bone in a vertical oblique plane, looking backwards. A. Membrana tympani. B. Malleus. C. Epitympanic space. D. Hiatus Fallopii. E. Cells extending into root of zygoma. F. Posterior wall of external meatus. G. Eustachian tube. H. Processus cochleariformis. K. Canal of tensor tympani.

**Caries and necrosis** of the temporal bone, occurring as events in the course of middle-ear disease, may be due either to ordinary pyogenic infection or to tuberculous disease. Extensive caries of non-tuberculous origin is not

common except as a subacute process in connexion with acute mastoiditis; the process takes place over small areas in many cases of chronic suppuration, either in the walls of the mastoid antrum or in the inner wall of the tympanum. Necrosis of the mastoid is comparatively common in cases of scarlatinal mastoiditis, the area involved being generally the outer wall of the antrum and a part of the posterior wall of the external meatus. Occasionally large areas of bone undergo necrosis, including the greater part of the squama and the root of the zygoma. Deep-seated necrosis generally takes place in connexion with infection of the labyrinth, and the separated bone may be composed of the whole or parts of the labyrinthine capsule. Tubercle in the petrous, as elsewhere, may lead to the formation of sequestra—which again are often labyrinthine—and to a widespread infiltration and caries of the petrous and mastoid parts. Where disease of bone is present, there is always discharge from the external meatus, and in many cases there are sinuses in the mastoid area.

*Treatment*, if it is to be of any avail, must be by the radical operation in all chronic cases, and in all, of whatever duration, by the total eradication of diseased tissue, and subsequent care until complete healing is attained. Where extensive infection of bone is present, there is no prospect of healing except by operation, while the risks of septic complications are large.

**Spontaneous facial paralysis,** occurring in connexion with middle-ear disease, is always an important sign of deep extension of the process. It is rare in acute otitis media. The nerve is attacked either through caries of the bony wall of the aqueduct of Fallopius or by involvement within an area of labyrinthine necrosis. It is doubtful if the occurrence of natural gaps in the bone of the Fallopian aqueduct predisposes to the occurrence of facial palsy, for many cases occur in which the nerve is without bony cover in part of its tympanic course without any harm resulting. The palsy is a typical lower segment one, the whole of the side of the face being affected. The prognosis will vary with the severity of the case and with its duration. It is rare in cases of chronic discharge for any improvement to take place unless a radical operation has been carried out. The nutrition of the facial muscles should be maintained as far as possible by galvanism and massage.

**Danger signals** in chronic suppuration of the middle ear.—Many chronic cases of middle-ear suppuration end with dramatic suddenness owing to the occurrence of rapidly fatal complications; there are nevertheless, as a rule, certain prodromal symptoms which herald the approach of these disasters. While aural surgery should intervene before the period of risk has commenced, the occurrence of these danger signals should be the limit beyond which a chronic suppuration should in no case be allowed to continue. They may be grouped as follows:—

*General symptoms.*—Fever, especially when high and sustained, markedly remittent, or punctuated by rigors.

*Local symptoms and signs.*—Severe pain in the ear, or in the mastoid; severe headache; tenderness over or behind the mastoid, in the suboccipital triangle, or in the upper deep cervical glands; facial paralysis; rapid loss of perception of sound through the cranial bones, vertigo, and vomiting; the symptoms and signs of increased intracranial pressure. With the appearance of most of these it will be probable that complications have already occurred, and a correct diagnosis and efficient treatment hold out the only chance of saving the patient.

**Deafness without discharge** when not due to obstruction in the external meatus, *e.g.*, by a ceruminous plug, may be due to changes in the middle ear,

the labyrinth, or the central nervous system and auditory trunk. The middle-ear deafnesses unaccompanied by discharge may be the legacy of past suppuration, or may be unassociated with suppuration at any period of their course. The former are usually due either to the presence of scar-masses in the tympanum, especially about the windows, or to alterations in labyrinthine tension due to disturbances in the position and tension of the chain of ossicles, and hence in the pressure exerted by the footplate of the stapes. It is worth making trial in these cases of the " artificial drum " of cotton-wool: this consists of a tampon or disc of wool pushed gently against the region of the stapes by a special forceps or introducer. The " drum " should be moistened with water, or if for prolonged wearing, with liquid vaseline. The improvement in hearing obtained by this simple artifice is sometimes surprising. India-rubber and other artificial " drums " than that of cotton-wool have wisely been discarded by most otologists.

The dry deafnesses of middle-ear origin unassociated at any part of their course with suppuration may be classified under the headings of Chronic catarrh of the Eustachian tube and tympanum and Otosclerosis. The diagnosis of these conditions is frequently difficult and is best studied in works devoted primarily to the diseases of the ear. The treatment of the catarrhal conditions requires a wide and thorough survey of the whole of the nasal, oral, and pharyngeal cavities, and the rectification of any causes of infection found there as a preliminary to the more special treatment of the local condition affecting hearing. There is no known treatment for otosclerosis.

**Malignant disease of the tympanum** may be either carcinomatous or sarcomatous. The former is probably in many cases due to the spread of the disease from the external meatus, but there is evidence that carcinoma may arise in the tympanum. Primary sarcoma of the tympanum occurs rarely. Both diseases are apt to be mistaken for an ordinary polypus. The prognosis is in all cases exceedingly bad.

### Diseases of the Internal Ear.

The knowledge of the diseases of the internal ear has much advanced in recent years, but is still very incomplete. Pyogenic infection has already been touched on under the heading of *Infective Labyrinthitis*. Syphilis is a not uncommon cause of disease of the internal ear both in the acquired and in the congenital forms.

In acquired syphilis deafness may come on at any period, from a few weeks after infection to as late as twenty years afterwards. In the early stages within two years of infection its onset is usually rapid, painless, and attended with loud tinnitus. There is great loss of sound perception through the cranial bones, and deafness may rapidly become almost complete. Vertigo is common. These cases have a very poor outlook. If salvarsan is used the patient should be warned that the result may be the total loss of hearing. On the whole the energetic use of mercury and iodides seems to be the wiser method in these cases. In the late cases the onset is much more gradual and the prognosis is better. These cases, even when of long duration, often do surprisingly well under salvarsan treatment. The difference in behaviour corresponds with what is known of the pathology of the two conditions, the early cases having an infiltration and destruction of the cochlea, the late ones showing a chronic patchy infiltration of the nerve trunk. In the congenital form the deafness appears usually in association with interstitial keratitis, not infrequently while the patient is under treatment for this. The deafness

is painless, of rapid progress, and exceedingly obstinate. Hearing is generally ruined. The onset is most frequent between the ages of ten and fourteen, and the majority of cases (about three-quarters) occur in girls. There is no special treatment.

Deafness of labyrinthine type is frequent in elderly men with raised arterial tension. Tinnitus may be troublesome, and there may be violent attacks of vertigo.

*Treatment* should be by mercurial pill and potassium iodide, a course of which will generally do much to relieve the vertigo and tinnitus. For the latter symptom ammonium bromide and hydrobromic acid are also of value.

**Menière's symptoms,** paroxysmal vertigo of labyrinthine type, with vomiting, unaccompanied by ear discharge, may be due to a wide variety of

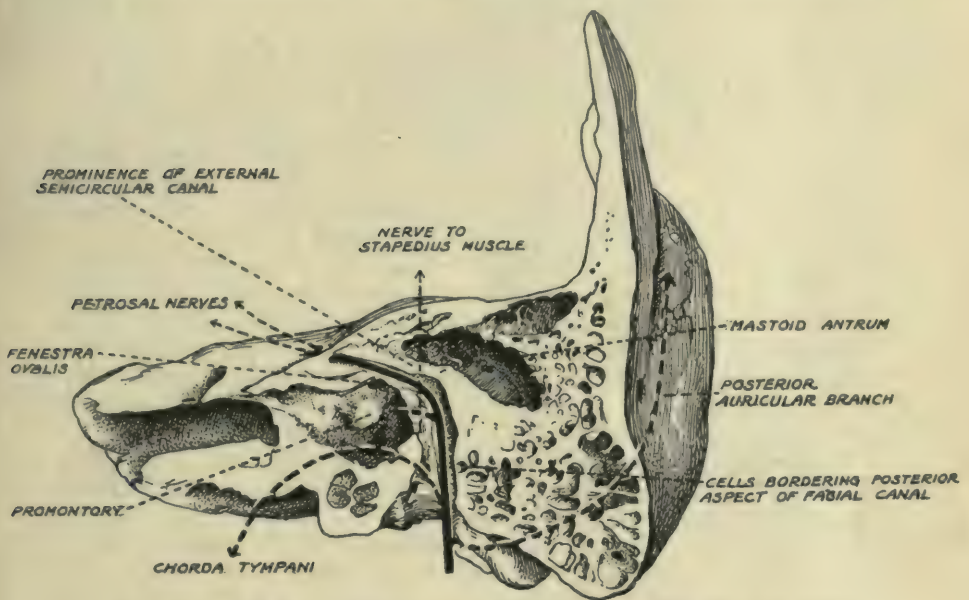



FIG. 177.—Semi-diagrammatic view of the relations and branches of the second and third parts of the intra-osseous course of the facial nerve.

causes, of which non-suppurative inflammation, syphilis, and vascular changes are the most important. The elevation of the symptom-complex to the level of a disease has resulted in much confusion and failure to analyse the underlying conditions. Menière's original case appears to have been either a hæmorrhagic labyrinthitis or a leukæmic hæmorrhage into the labyrinth. The latter condition is a well-recognised though infrequent complication of leukæmia.

Hæmorrhage into the labyrinth, with resulting vertigo and loss of labyrinthine function, occurs as a prominent feature of the condition produced in men working under pressure—divers and caisson workers—if decompression is not carried out with sufficient deliberation.

**Auditory vertigo,** besides being a part of those conditions just mentioned, may be due to the most diverse causes, such as the pressure of a plug of cerumen, the contraction of scar-tissue in the tympanum, the pressure of effusions or cholesteatoma in the tympanum, the presence of a fistula of the external or superior semicircular canal, acute infection of the labyrinth, or

the complete functional destruction of the labyrinth on one side. Vertigo of labyrinthine type may also be the aura of an epileptic fit or may be the form of manifestation of minor epilepsy. Finally, vertigo may be the result of disease of the cerebellum, of ocular defects, or of the gastric disturbance known as a " bilious attack."

*Treatment* should in all cases depend on the discovery of the cause. The condition of the labyrinth should be thoroughly investigated and a general survey of the patient's physical condition be carried out.

**Tinnitus aurium,** subjective noises in the ears, may arise under a wide variety of conditions, and the sensations complained of may assume a number of different types, such as humming, rushing, whistling, pulsating, or more rarely sudden loud explosive sounds. Almost any abnormal condition of the auditory apparatus may be the cause ; in the external meatus, the pressure of cerumen on the membrana tympani, or slight œdema spreading from a furuncle ; in the middle ear, effusion, scarring, or retraction of the membrane, fixation of the footplate of the stapes ; in the labyrinth, alterations of the normal perilymphatic pressure, inflammation of the membranous structures, changes and degenerations in the nerve endings ; in the central nervous system, inflammations and degenerations of the auditory roots, ganglia, or central tracts ; in the vascular system, abnormalities of arterial tension, either in excess or defect, such as are produced by arterio-sclerosis, valvular disease, or anæmia. Pulsating tinnitus is always of vascular origin. In addition, certain drugs, especially salicylates and the derivatives of salicylic acid, and quinine, may produce a loud tinnitus, which as a rule disappears when the administration is stopped, but may be permanent in bad cases.

*Treatment.*—This should always rest on the formation of a diagnosis of the cause, and should be directed to its removal whenever this is possible. Much symptomatic relief may be obtained by the use of bromides and hydrobromic acid. Sometimes patients benefit greatly from galvanism.

**Drug deafness** may result from the action of salicylates or of quinine. That due to salicylates is usually temporary, but may be lasting ; that due to quinine is often in large part permanent. The stoppage of the drug is of course essential to recovery. Quinine deafness is common among those who live in malarial countries. Individual susceptibility to the action of these drugs varies widely. Their results seem to depend on a direct toxic action on the nerve-endings in the cochlea.

**Gunner's deafness** has increased in frequency greatly since the introduction of powders of the cordite class. Among artillerists it affects those who have to do with the smaller class of gun. Cases are also not uncommon among sportsmen who are fond of " hot corners," or who shoot much with modern high-velocity sporting rifles. The deafness is of labyrinthine type, affecting both ears among service men, and one ear only as a rule among sportsmen. It might be entirely prevented and the waste of many valuable servants of the State avoided by the simple precaution of wearing plugs of plastic material in the ears whenever gun firing takes place. The effect, once produced, is incurable, though some improvement up to a fixed point may take place during the early days after heavy exposure. Of the same nature is **Boiler-maker's deafness.**

During the late war a vast number of cases of " explosion deafness " occurred, the features of which differ from ordinary " gunner's deafness." They are caused by exposure to single or repeated heavy detonations at close range, and whereas ordinary gunner's and boilermaker's deafness results from degenerative changes in Corti's organ and is of gradual onset, these

cases seem to be caused by a mechanical disorganisation in this region through sudden and enormous pressure change. The membrane may be split or sometimes " blown out " by the violence of the shock. It is interesting that some of these cases of rupture escape the effect on the cochlea almost entirely, and it is rather the exception for men with old open perforations of good size to show true explosion deafness after exposure to detonation. The extent of the damage, which is rarely complete in both ears, can only be estimated after an interval. There is at first a large element of cortical deafness due to excessive stimulation, and in its nature protective. This may be prolonged as an hysterical deafness (always total), but usually lessens after a few hours. The residual deafness is labyrinthine in type and may show progressive slow improvement for many weeks, but as a rule leaves a permanent impairment of serious degree. Subjective noises of a hissing and roaring nature are often troublesome, the extent of this depending chiefly on the sufferer's nervous condition.

**Head injuries** may produce deafness by cicatrisation of the external meatus or by some variety of basal fracture, which may result in cicatricial closure of the Eustachian tube, disorganisation of the tympanum, or fracture through, and destruction of, the labyrinth.

## The Bacteriology of the Middle Ear.

The inflammations of the middle ear and its adjoining cavities are due to bacterial invasion. There are two possible routes open through which this might take place, that from the pharynx through the Eustachian tube, and that from the outside through the external auditory meatus. The former is the pathway of infection in all the primary cases of middle-ear inflammation; acute otitis media is always an extension of a pharyngeal infection. Nor does the importance of the pharyngeal route end with the stage of acute otitis media; throughout the course of a chronic suppuration there is no question that renewed infection may and often does take place through the Eustachian tube. The importance of infective conditions of the pharynx and in a secondary degree of the mouth in the prolongation of middle-ear suppurations will be easily understood. Above all things the presence of adenoids in the naso-pharynx with their accompanying condition of continued muco-purulent catarrh is most unfavourable to the cessation of a middle-ear suppuration, and almost inevitably brings about relapse if it has ceased. Infection from without through the external meatus only takes place in the presence of pathological defect in the membrane or through traumatic opening of the middle-ear chamber. By this channel may be introduced a great variety of pathogenic and non-pathogenic organisms, such as figure so largely in the bacteriology of the chronic suppurations.

Middle-ear suppurations are to be viewed as a particular group of infective processes, owing their peculiar features to the anatomical arrangement of the parts, and not to any special properties of the tissues involved. The pathology of the ear is the pathology of the rest of the body.

In the acute otitis media of children, the infective agent is most commonly the *streptococcus pyogenes*, occasionally the pneumococcus, salivary types of streptococci, or staphylococci. The destructive middle-ear inflammations attending scarlet fever and measles are almost always streptococcal. In the otitis of diphtheria it is rare to find the Klebs-Loeffler bacillus, infection being generally due to the *streptococcus pyogenes*. The staphylococcal cases tend to be of a less acute form, but on the other hand show much obstinacy and

are apt to become chronic. In adults pneumococcal otitis is relatively much more common. When mastoiditis follows, the pus gives in nearly all cases a pure culture; in children the *streptococcus pyogenes* is present in the great majority of cases; in adults, on the other hand, fully half the cases are due to the pneumococcus. Streptococcal mastoiditis is generally much more rapid in its development than is that due to the pneumococcus. Of the staphylococci, both *staphylococcus pyogenes aureus* and *albus* are found, the acuteness of the inflammation being more marked in the case of *aureus*. Mastoiditis is rare in staphylococcal cases.

In chronic suppurative otitis media a wide variety of organisms may be discovered, most of them being of little pathological significance. Culturally the group of cocci is usually thrown into the background by the preponderance of organisms of the *proteus* and *coli* groups; in addition, yeast forms and leptothrix are frequently present in films. In film-preparations it is generally impossible to form any conclusion as to the truly efficient elements in the flora displayed. On the other hand, as soon as serious intracranial extension of the disease takes place, the streptococci come suddenly to the front, so that in cases of meningitis or sinus thrombosis almost pure cultures of *streptococcus pyogenes* are often obtained. The great majority of all cases of sinus thrombosis are streptococcal, with only secondary invasion by the mixed flora of the middle ear. Particularly in cholesteatoma, a number of innocent diphtheroids are often found and may easily be mistaken for the Klebs-Loeffler bacillus.

# Section X.

## SURGERY OF THE EYE.

**Physical examination.**—The eyes should be examined :—

1. By the unaided sight in good daylight, and in the dark room by focussing the light from an electric lamp on to the eye by means of a convex lens. For fine details a small lens having a magnification of ten diameters should be used in conjunction with the focal illumination.

2. By the ophthalmoscope.

3. For acuity of vision, fields of vision, tension, etc.

Both eyes should always be examined.

*On external examination* the following points should be looked for :—The position and movements of the eyes, to discover the presence of a squint, paralysis of a muscle, or of proptosis ; the condition of the lids and lashes as to the presence of ectropion, entropion, or blepharitis. A prominence in the region of the lachrymal sac will indicate a collection of mucus or pus in it. The lids should be examined for Meibomian cysts, and the conjunctival surface, after eversion of the lids, for acute inflammation due to recent infection or for scarring, the result of past disease ; the cornea for an ulcer or foreign body, or for nebulæ, the residue of antecedent inflammation. The ocular conjunctiva should be examined for injection of its vessels, which are brick-red and can be moved over the underlying globe, in distinction to the diffuse pink flush which indicates an inflammation of the deeper structures, cornea, iris, or ciliary body, and which is limited to a zone of varying width immediately surrounding the cornea.

Observations should be made on the pupils as to reactions, size, etc. The intra-ocular tension should be estimated.

**The ophthalmoscope.**—No description of the use of the ophthalmoscope is of value ; it must be learned by practice and demonstration. There are two methods of use—the indirect and the direct ; each has its particular advantages.

By means of the *indirect method* a more extensive view of the fundus is rapidly obtained, and it is immaterial whether the eye is emmetropic or highly hypermetropic or myopic. The magnification obtained is about four diameters.

The *direct method* has certain limitations, but it is much the more valuable. It should be made a routine to examine first with a + 12 lens behind the hole in the mirror, and then slowly one by one to revolve the lower lenses + 10, + 8, + 7, etc , behind the aperture till no lens is present.

By this means many valuable observations are made which otherwise are apt to be overlooked. Thus with the higher lenses the cornea, iris or lens is in focus, and abnormalities of these, such as the residue of vessels in the cornea from interstitial keratitis, punctate keratitis, posterior synechiæ, or lens opacities, are seen. As the lower lenses are in turn interposed, the deeper parts of the lens and the vitreous come into view, until, with a clear hole, the details of the patient's fundus for the first time are seen in sharp focus if he is emmetropic. If he is not emmetropic his refractive error may be estimated approximately by this means.

Thus in Fig. 178 (*a*) if the patient is emmetropic and his accommodation relaxed, rays emerging from a point on the retina A will be parallel as they leave the eye, and will therefore come to a focus on the observer's retina if he too is emmetropic; he will, in fact, see the details of the patient's fundus in focus. If there is a structure in the patient's eye further forward, as at B, Fig. 178 (*b*), be it the whole retina, as in hypermetropia, or the summit of a neoplasm, or detached retina, etc., rays emerging from this point will be divergent as they leave the eye and will come to a focus behind the observer's retina; the image therefore will be blurred. If these diverging rays are brought parallel by

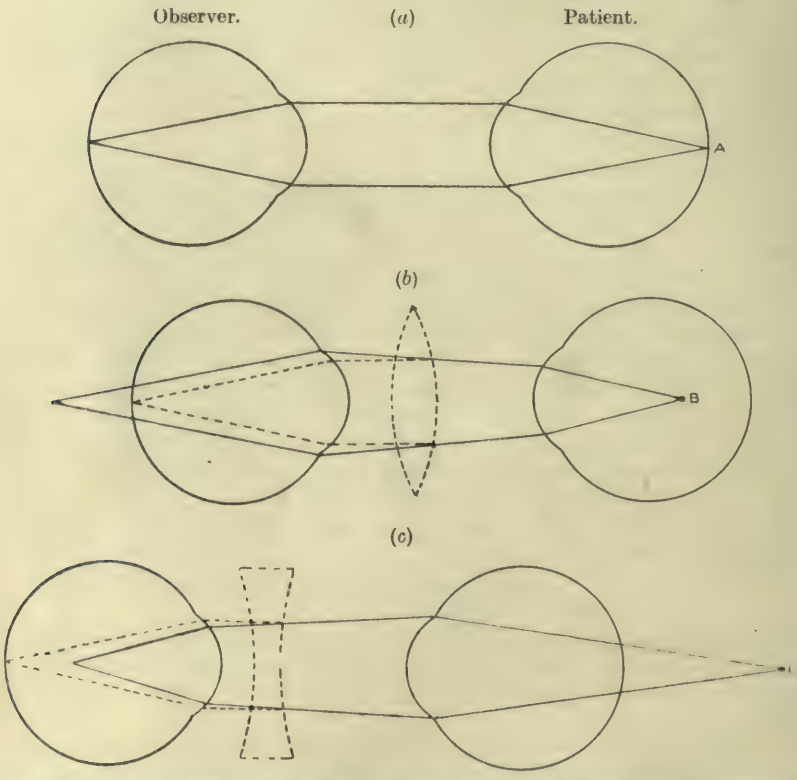



FIG. 178.—Diagrams to illustrate the method of approximate estimation of a refractive error by direct ophthalmoscopy. (*a*) The emmetropic eye. (*b*) Illustrating hypermetropia. (*c*) Myopia.

means of a convex lens of appropriate strength behind the hole in the ophthalmoscope mirror, the structure will be seen clearly and in focus (Fig. 178 (*b*)). The further forward the point B the more divergent will be the emerging rays, and the higher, therefore, the convex lens required to bring them parallel, and so to produce an image in sharp focus on the observer's retina.

It will be seen that the strength of the lens in the ophthalmoscope is a direct measure of the position of the point B, and hence a direct measure of the degree of hypermetropia, of the swelling of the optic disc, or the prominence of a choroidal sarcoma, etc.

In the case of a structure at the point C, Fig. 178 (*c*)—*e.g.*, a myopic eye, a cupped optic disc, etc.—the same remarks hold good, except that concave

lenses will be needed instead of convex. In making these observations it is essential that the observer keep his accommodation relaxed.

A further advantage of the direct method is that the magnification obtained in an emmetropic eye is fifteen diameters. Thus in the retina, as nowhere else in the body, one is able to examine the very small blood-vessels during life under a considerable magnification.

The normal optic disc (Plate 3, Fig. 1) is paler than the rest of the retina; it is circular, 1.5 mm. in diameter, often fringed in part by pigment, and its centre, where the retinal vessels enter and leave the eye, is usually depressed in the form of a cup or funnel; this is the "physiological cup." Sometimes the disc has a stippled appearance over a part of its area, a condition which is often marked in optic atrophy; it is due to the exposure of the lamina cribrosa.

A physiological condition which is apt to be mistaken for a pathological one, is the presence of white patches of medullated nerve fibres. They usually have an obviously striate texture, the striations radiating from the edges of the disc, and overlying the retinal vessels in places. The patches are not present at birth since medullation does not occur till about the second month; they disappear if optic atrophy occurs.

The retinal veins are rather larger and darker than the corresponding arteries. Pulsation is frequently visible in the veins on the disc, and is easily elicited in the arteries by pressing on the globe with the finger, so as to increase the intra-ocular pressure to a point in excess of the diastolic pressure in the artery.

The yellow spot is so called from its distinctly yellow colour in the post-mortem room; it is not yellow as seen with the ophthalmoscope. It is an inconspicuous spot, and beginners always have difficulty in identifying it. It is recognised from the fact that it is about two discs breadth to the temporal side of the disc itself, in an area where no blood-vessels are visible. It is usually of a rather deeper red than the surrounding retina, and sometimes is seen as a highly refractive spot.

When the pigment in the retina and choroid is sparse, the pattern of the choroidal vessels is plainly seen.

*The acuity of vision* is estimated by means of standardised type, which is so constructed that each portion of the letters subtends an angle of one minute at the eye at a distance of six metres. If the patient can clearly distinguish each part of a letter, he recognises it, and his vision is normal, or 1, or, to indicate the distance at which the test is made, $\frac{6}{6}$. Larger letters are supplied for those whose visual acuity is defective; thus, the largest letter is ten times the size of one in the normal line, and if the patient can see only this letter at a distance of six metres, his visual acuity is one-tenth of the normal, or $\frac{6}{60}$, and so on.

The taking of the visual fields is of great importance, and is done by means of a perimeter.

Important changes in *the fields of vision* occur in local diseases of the eye—*e.g.*, glaucoma, optic atrophy, etc.—and as a result of lesions within the skull, such as pituitary tumours; lesions of the optic tract, of the mid-brain involving the anterior corpora quadrigemina, external geniculate bodies, or optic thalamus; hæmorrhage or wounds involving the optic radiations; or lesions involving the visual cortex in the occipital lobe.

Thus in glaucoma the upper part of the nasal field of vision is first contracted (Figs. 179 and 181), in pituitary disease the upper part of the temporal field is usually the first to be reduced (Figs. 180 and 182), whilst a left homonymous

## VISUAL FIELDS.

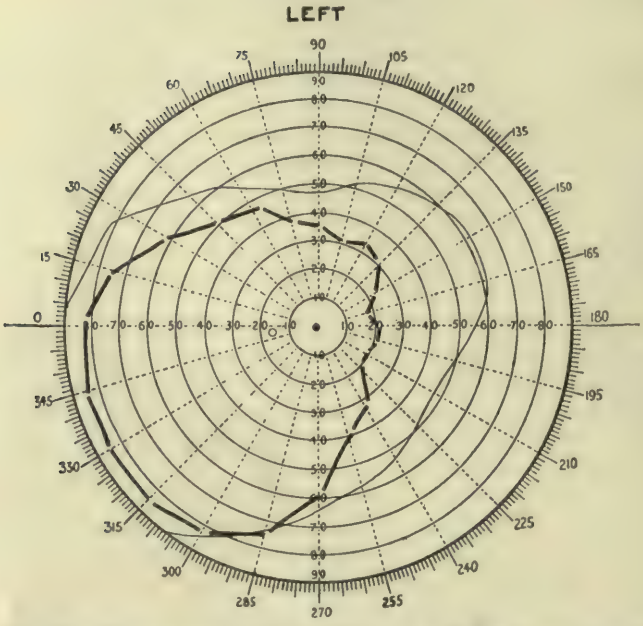



FIG. 179.—From a man of fifty-nine years suffering from chronic glaucoma.

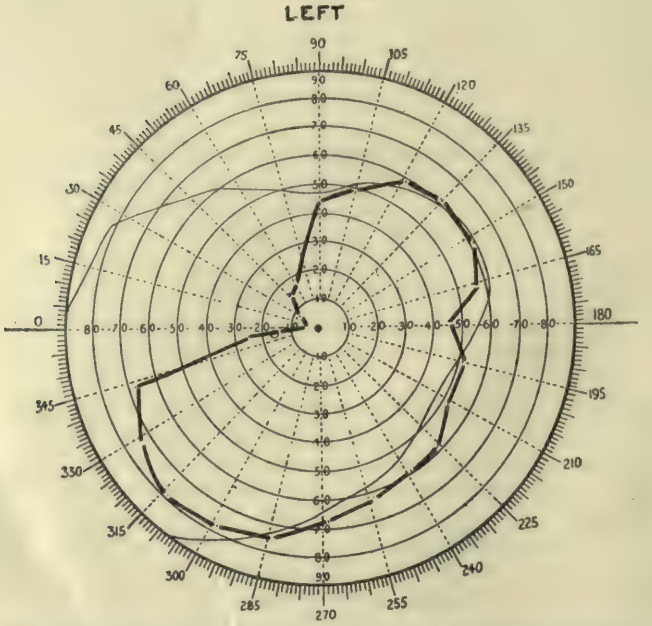



FIG. 180.—From a boy of seventeen years suffering from a pituitary lesion. Contrast the loss of the temporal fields of vision in pituitary lesions with the loss of the nasal fields in glaucoma.

## VISUAL FIELDS.

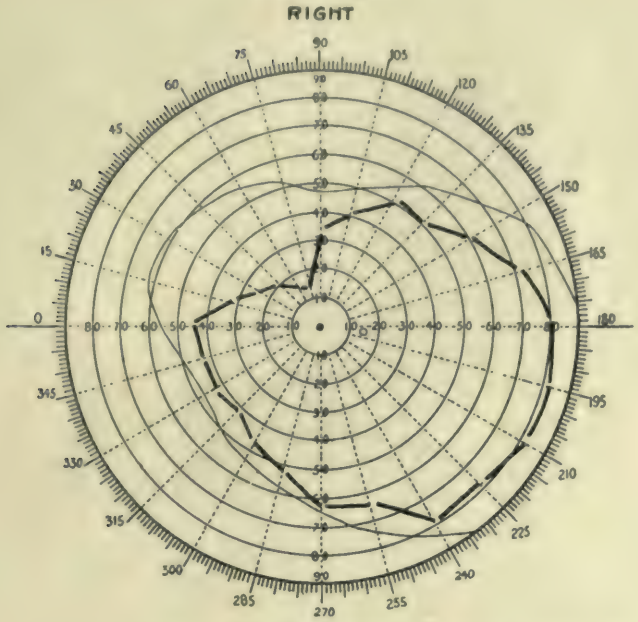



FIG. 181.—From a man of fifty-nine years suffering from chronic glaucoma.

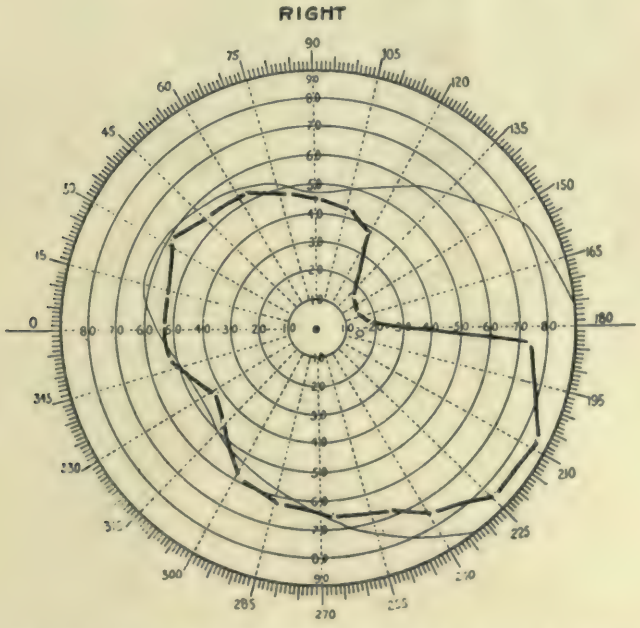



FIG. 182.—From a boy of seventeen years suffering from a pituitary lesion. Contrast the loss of the temporal fields of vision in pituitary lesions with the loss of the nasal fields in glaucoma.

hemianopia, for instance, will be produced by embolism of the right posterior cerebral artery which supplies the visual area in the right occipital lobe (Figs. 183 and 184).

*The tension of the eye* may be estimated roughly by digital examination, when variations from the normal are expressed as + 1, + 2, + 3, or − 1, − 2, − 3. Several reliable forms of tonometer are available for estimating the tension more accurately; the normal is between 17 and 30 mm. of Hg.

### Diseases of the Lids and Lachrymal Apparatus.

**Ciliary blepharitis** is due to infection of eyelash follicles with the *staphylococcus aureus*. It occurs for the most part in children in poor condition. It

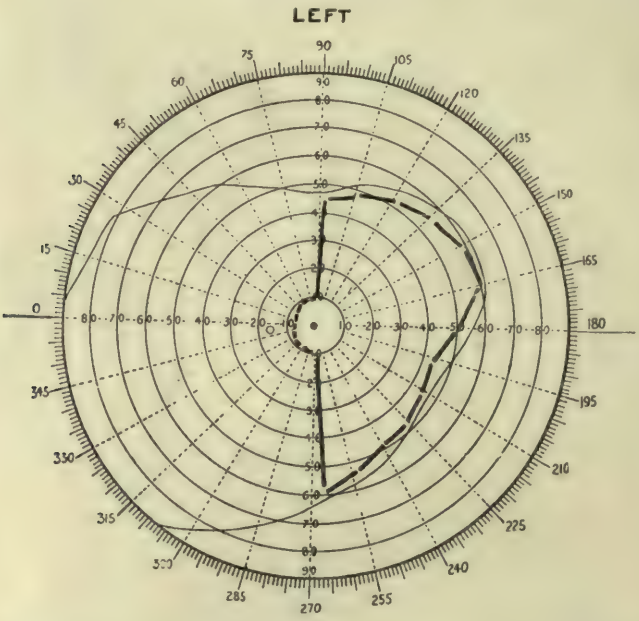



Fig. 183.—From a man of sixty-three years who had symptoms of thrombosis of the right posterior cerebral artery.

is very chronic and may give trouble for many years, periods of improvement alternating with recurrences. Ulceration occurs along the line of emergence of the hairs, which fall out and become scanty and ill formed. Scarring follows the ulceration, and the lashes as they grow can no longer find their way through the scar tissue, and so grow through the intermarginal space; as a result of this, instead of standing away from the cornea, some come to turn inwards, scraping the corneal surface and causing ulceration (Fig. 185). To this condition the term *trichiasis* is applied.

*Treatment.*—If the general health appears impaired it should of course be looked to. If a refractive error is present, nothing but good will come of its correction. Locally the lids should be bathed with the following lotion used warm three times a day:—Sodii Bicarb., gr. l.; Sodii Bibor., gr. l.; Liquor. Carbonis Detergent., ♏x.; Aquam, ad ʒx. After getting the lids quite clean

and dry the following ointment should be gently rubbed into the ciliary margin: —Hydrarg. Ox. Flav., gr. v.; Vaseline Alb., ad ʒj. If the lid margin is ulcerated, it should be painted twice a week with a solution of silver nitrate gr. x. ad ʒj.

A primary syphilitic chancre sometimes occurs on the lids, most often on the conjunctival surface of the lower. As in other extra-genital chancres, the lymphatic glands, pre-auricular and submaxillary, are much more enlarged, and are softer, than is the case with the glands in the groin in genital chancres.

The lids are sometimes the site of a vaccine pustule, usually in the mother of a child who has recently been vaccinated. The cornea, being avascular, is not affected, and serious results seldom follow.

## VISUAL FIELDS.

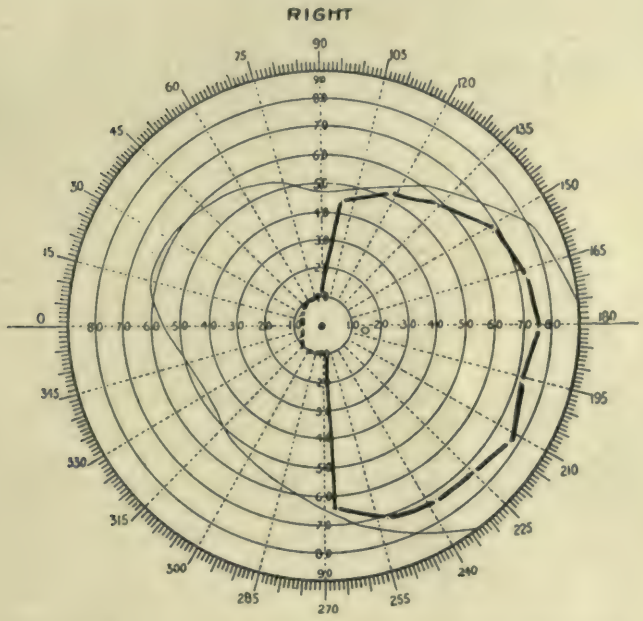



FIG. 184.—From a man of sixty-three years who had symptoms of thrombosis of the right posterior cerebral artery.

**Meibomian cysts** are the commonest tumours of the lids. They are due to a collection of the secretion, from blocking of a duct, and later there is the formation of a low grade granulation tissue within them. They are oval in shape, the long axis being vertical; the skin is freely movable over them, and, as the glands are in the substance of the tarsal plate, which is the most posterior structure in the eyelid, they show on the deep aspect of the lid as a purplish area, and not infrequently ulcerate through on this surface.

*Treatment.*—Twenty minims of a 2 per cent. solution of novocaine should be injected under the surrounding skin. After an interval of five minutes the lid should be everted and some solid cocaine hydrochloride rubbed over the purplish area. An incision is then made into the cyst along its long axis and the contents scraped out with a small sharp spoon.

**Entropion** is the name applied to inversion of the lids. It is best seen in cases of long-standing *trachoma*, where the cicatrisation which occurs on the posterior surface of the lid produces it (Fig. 186). It often results in the turning in of the eyelashes—*trichiasis*—with its accompanying irritation and ulceration of the cornea. The *treatment* is operative.

**Ectropion** implies eversion of the lids, usually the lower one only. It may be produced by scarring of the skin surface of the lid, but in old people it often starts as a sagging of the lower lid, owing to loss of tone in the orbicularis palpebrarum. The *treatment* is operative.

By **symblepharon** is meant the formation of an adhesion between the lid and the eyeball. The severest form results from a burn by lime or other caustic.

**Styes** are abscesses formed around follicles of eyelashes. They are painful, and when recurrent often indicate temporarily impaired health. By way of *treatment* it may be sufficient to pull out the affected eyelashes, but in some cases incision and fomentations are necessary.

**The lachrymal apparatus** consists of the lachrymal gland which secretes the greater part of the tears, and the punctum and canaliculus in each lid, which drain into the lachrymal sac, and thence into the nasal duct. The nasal duct opens into the inferior meatus of the nose under cover of the inferior turbinal bone at the junction of its anterior and middle thirds.

FIG. 185. — Diagram to illustrate the method of production of trichiasis in chronic ciliary blepharitis.

The lachrymal gland is seldom the site of disease, but occasionally tumours of the mixed parotid type occur. In spite of the very frequent infection of the conjunctival sac, infection or abscess of the gland is almost unknown. If removal becomes necessary the accessory glands in the conjunctiva are usually sufficient for the needs of the eye.

The most important disease of the lachrymal drainage system results from obstruction to the nasal duct. This is caused by syphilitic disease of the bony canal, ulceration of the mucosa with stricture formation, and sometimes by disease of the nose. At first watering of the eye—*epiphora*—occurs. The next stage is distension of the sac by mucus owing to the chronic infection, and sooner or later muco-pus and pus replace the mucus. When this stage is reached it is only a matter of time for infection of the surrounding cellular tissue to occur, and for the abscess to burst externally. This takes place over the lower part of the sac and below the tendo oculi.

The presence of watering of the eye, a soft swelling in the position of the sac, and the fact that pressure over the swelling causes regurgitation of its contents into the conjunctival sac through the puncta, suffice for the diagnosis. The presence of an abscess which is in direct connexion with the conjunctival sac is a constant menace to the integrity of the cornea.

*Treatment.*—In a few cases syringing the sac through the canaliculi will bring about a cure. Probing is useless and harmful. By way of radical treatment, the sac should either be removed entire, or a fresh opening into the nose made by chiselling away portions of the superior maxilla and lachrymal bone, just in front of the middle turbinal bone, from inside the nose, and removing a portion of the inner wall of the sac (West's operation).

### Diseases of the Conjunctiva.

At different times the conjunctiva becomes infected by a variety of organisms, and the different types of conjunctivitis resulting are in considerable measure clinically characteristic. Whatever the organism, the conjunctival vessels are injected, there is secretion of muco-pus or pus, and this, drying on the lashes during the night, causes the lids to be gummed up in the morning.

Mild forms of the disease are *chronic catarrhal conjunctivitis*, due to the *staphylococcus aureus; follicular conjunctivitis*, in which there is considerable enlargement of lymphoid follicles, more especially in the lower fornix; *angular conjunctivitis*, due to the Morax-Axenfeld bacillus, and, as its name implies, chiefly confined to the inner and outer canthi; and the *acute conjunctivitis* due to the Koch-Weeks bacillus, in which at times there is so great a secretion of pus as to simulate gonorrhœal ophthalmia; the last variety is contagious. They usually only require the frequent use of lotions such as the following, and the application of a simple ointment to the edges of the lids at night, to prevent them becoming stuck together. The eyes should not be bandaged, but a shade may be worn :—

℞ Acidi Borici . . . . . gr. j.
Zinci Sulph. . . . . gr. x.
Aq. ad . . . . . ℥x.
℞ Methylene blue $\frac{1}{2000}$ in normal saline solution.
℞ Zinci Chloridi . . . . . gr. v.
Aq. ad . . . . . ℥x.
℞ Zinci Sulphocarb. . . . . gr. xx.
Aq. ad . . . . . ℥x.

In the more chronic cases it is advantageous to paint the conjunctiva twice a week with a solution of silver nitrate gr. v. ad ℥j., or with 20 per cent. protargol solution.

**Gonorrhœal conjunctivitis** is due to infection of the conjunctiva with the gonococcus; in many cases it leads to loss of the eye, and in others to very great impairment of sight. It occurs in two chief forms. In one the infection is derived from the maternal passages during birth, giving rise to the commonest form of ophthalmia neonatorum; the other results from infection by the finger or towel, usually in those who are at the time suffering from a recent urethritis.

In infants, as is to be expected, both eyes are usually involved. Two or three days after birth an acute inflammation develops, the conjunctiva is red and swollen, hæmorrhages occur into its substance, a thin false membrane forms on its surface, and it soon becomes almost raw. The lids are swollen and tense, and large quantities of thick yellow pus are secreted in which the coccus is found. Ulceration of the cornea usually follows, commencing at its edges, and perforation commonly occurs. The iris then becomes adherent to the cornea, forming what is known as an anterior synechia. The eye may now go on to complete destruction, or repair may set in. In the latter event a dense corneal leukoma is formed, with the iris adherent to it; a small opacity forms on the front of the lens—anterior polar cataract—owing to its apposition to the inflamed and perforated cornea, and later nystagmus usually occurs. Milder cases are seen, especially if silver nitrate has been dropped into the eyes at birth.

In adults, as is to be expected from the means of conveyance of the organism,

one eye only is commonly affected, but otherwise the general course of the disease does not differ, except that it is more severe.

There is a very big difference between starting treatment at the *time of infection*, as in the prophylactic silver nitrate treatment of infants' eyes at birth, and beginning it when the *disease is manifest*, as in the adult.

*Treatment.*—In the infant the general health must receive every attention. The eyes should be washed out night and day with a simple lotion, *e.g.*, warm normal saline, as often as pus collects; this will be about every twenty minutes. The child's sleep, however, must not be sacrificed to the treatment. The conjunctiva should be painted with a solution of silver nitrate gr. v. ad ʒj. once a day. If the lids are tense the external canthus should be slit up to the outer margin of the orbit; this facilitates the escape of pus and the washing of it away, and prevents spasm of the lids. The wound heals leaving almost no scar, and does not require stitching.

Similar lines of treatment are suitable in an adult, but since as a rule one eye only is affected, and the results are so deplorable, the greatest possible precautions must be taken against infection of the other eye. This infection may be brought about during irrigation, by the patient rubbing the eye with the hand or handkerchief which has been in contact with the infection, or by lying with the good eye against the infected pillow. Fortunately the gonococcus does not long survive drying, and this accident is not often seen. There should be no hesitation in slitting the outer canthus early. Vaccines are useless. A watch-glass incorporated in adhesive plaster may be fixed over the sound eye to prevent infection; this will require changing daily. Holes should be cut in the plaster to provide for the escape of moisture, and the inner surface of the glass rubbed over with soap and then polished to prevent dimming with moisture.

During the late war some men purposely infected one of their eyes, usually the right one.

**Pneumococcal conjunctivitis** is characterised by the secretion of a good deal of thick yellow pus, and clinically it somewhat simulates a mild gonorrhœal ophthalmia. It is, however, much less virulent, and need not cause great anxiety.

**Diphtheritic conjunctivitis** is rare; it is characterised by the formation of a thick greyish false membrane, chiefly on the palpebral conjunctiva, with brawny infiltration of the tissues of the lid and general constitutional disturbance; it is not necessarily associated with nasal or pharyngeal diphtheria.

*Treatment.*—Locally the eye should be treated with warm bathings, fomentations, quinine drops, and atropine. Antidiphtheritic serum should be injected without delay. The Xerosis bacillus, which is with difficulty distinguishable from the Klebs-Loeffler bacillus, is almost a normal inhabitant of the conjunctival sac, and may give rise to confusion if this is not borne in mind.

**Streptococcal conjunctivitis.**—Most cases of conjunctivitis in which the streptococcus is found run a rather mild course, and cause no serious trouble; on the other hand, ophthalmia neonatorum is sometimes caused by it, and these cases may be even more dangerous than those due to the gonococcus. A false membrane is formed, the lids are thickened and brawny, and the cornea becomes ulcerated. The condition of the lids may continue in a more or less unchanged state for years.

**Trachoma** is an infectious disease of the conjunctiva which runs a very chronic course. It infects the cornea, and when it is cured, leaves behind permanent residues which cause serious trouble for many years or for the rest of the patient's life. From its course and infectious nature it seems certain

that it is due to a micro-organism, though this has not been isolated. During the late war trachoma gave rise to little trouble owing to the precautions taken. Large numbers of the Chinese in France suffered from it, and on this account all the Chinese were divided into three groups: those who certainly had trachoma, those who certainly had not got it, and those in whom its presence was doubtful.

The disease starts in some cases as an acute conjunctivitis, in others insidiously. The palpebral conjunctiva soon becomes acutely inflamed and velvet-like, and bright red granulations appear on it where it covers the tarsal plate, and especially in the fornices. The changes are always more marked in the upper lid, a point which is often of importance in differential diagnosis. Sometimes the granulations are so prominent that they can be expressed by pressure, and this is one form of treatment. Soon the upper part of the cornea becomes infected, and blood-vessels grow in over its surface. After some time scar tissue begins to be formed in place of the granulations, and ultimately the granulations are completely replaced by it. As this fibrous tissue on the posterior surface of the lids contracts, the lid margins, with the lashes, tend to turn inwards (entropion), until in bad cases the eyelashes come to sweep over the cornea, causing irritation and ulceration (Fig. 186). As a result of this, the cornea, its transparency already impaired, becomes the seat of repeated small ulcers, which leave nebulæ as they heal, and spoil the already greatly-impaired sight still further.

Fig. 186. — Diagram to illustrate the method of production of trichiasis resulting from trachoma.

*Treatment.*—Special schools are provided for children with trachoma, since prevention of spread of the disease is of first importance. In the acute stage the surface should be rubbed with a smooth crystal of copper sulphate every other day, and copper sulphate drops grs. ij. ad ʒj. used three times a day. If granulations are prominent they may be expressed with special forceps. Later, silver nitrate or protargol may replace the copper sulphate, and as the disease subsides simple lotions may be used. In bad cases the best treatment is actually to dissect away the tarsal plate with the diseased conjunctiva overlying it. Entropion and trichiasis may require operation later.

**Phlyctenular conjunctivitis** is a mild conjunctivitis which is characterised by the development of one or more localised nodules of small-celled infiltration around the corneal margin. The nodules may break down and form small ulcers. They are usually seen in children who are in poor health, and are not a tuberculous lesion, as is sometimes taught. A simple lotion, iron, good food, and good hygienic surroundings are all that is necessary by way of treatment. Sometimes they occur in the cornea itself, giving rise to a phlyctenular ulcer; they are then more difficult to cure and often recur; permanent nebulæ are usually left. In other cases the disease takes the form of a diffuse involvement of the corneal epithelium—*phlyctenular keratitis*. This is often an exceedingly chronic condition, which continues with relapses for many months and leaves disabling corneal opacities.

The need for general treatment is usually clearly indicated; locally atropine should be used combined with hot bathing, and if ulcers of any considerable size occur they should be carbolised. Again, the marginal phlyctenule, instead of healing rapidly, may start to invade the cornea and make a linear

track across it, the advancing margin being an active ulcer which is followed up by a leash of blood-vessels. In this way a band-like nebula, a millimetre or so in width, may be formed two-thirds of the way across the cornea, and if it crosses the pupil, vision will be seriously impaired. This ulcer is known as a *leash ulcer;* its progress may be stopped by carbolising the advancing edge.

These various forms of phlyctenular disease are one in this, that they involve epiblastic tissues only, for the epiblastic layer of the conjunctiva is continued over the cornea, as is well shown by the fact that when the snake sheds its skin it also sheds this layer of the cornea.

A **pinguecula** is a yellowish swelling which occurs on either side of the cornea. It is composed of a thickening of the conjunctiva and subconjunctival tissues. It is triangular in shape, with its base abutting against the corneal margin, but never invades the cornea and is of no significance.

A **pterygium** is a thickened band of conjunctiva drawn up into a fold and invading the inner portion of the cornea; it may advance as far as the level of the pupillary margin. After removal pterygia tend to recur. They are seldom seen in this country.

## Diseases of the Cornea.

Small foreign bodies frequently become impacted in the cornea. They give rise to watering and irritation and to a mild degree of injection of the eye. They cause much less trouble than if fixed to the under-surface of the lid, for in the latter case every movement of the lid scrapes the foreign body over the surface of the highly sensitive cornea. They are usually easily removed after cocainising, either by a wisp of cotton-wool, or, if firmly fixed, by a blunt spud or a sharp needle.

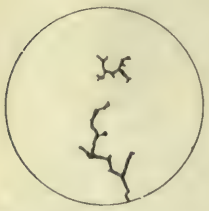


Fig. 187.—Diagram to illustrate a dendritic and a stellate corneal ulcer.

It is a common occurrence for those working with an emery wheel to get a minute fragment on the cornea, which after removal leaves a brown ring. This ring is burnt cornea, and no attempt should be made to scrape it away.

During the late war many cases were seen in which the cornea was very freely spattered with innumerable grains of fine sand, which it was quite impossible to remove individually. These eyes have become quite quiet, with hundreds of brightly refracting granules still visible in the substance of the cornea, causing no trouble.

An abrasion of the cornea is a common accident; as a rule the epithelium is removed down to Bowman's membrane. It is a painful condition, and causes free watering of the eye. If the abraded area cannot be seen, it is rendered conspicuous by dropping fluorescine solution into the eye, by which it is stained a bright green. *Fluorescine* is useful in indicating that an area of the cornea is denuded of epithelium, as in an abrasion or corneal ulcer. In the latter case, if the epithelium has covered its surface, even though repair is not complete, no staining occurs.

**Corneal ulcers.**—A number of varieties of corneal ulcers occur which have distinctive features and run characteristic courses.

**Phlyctenular ulcers** have been referred to.

A **dendritic ulcer** involves only the superficial corneal layers and is usually a sequel to a febrile attack. It commences at the corneal margin, and, keeping

a linear form, spreads in a dendritic manner (Fig. 187). If left, it continues to spread and is very long in healing. The *treatment* is cauterisation.

**Serpiginous ulcers** involve the deeper layers of the cornea, and may result in perforation; they are caused by the pneumococcus.

The term **hypopyon ulcer** is applied to any deep ulcer which is accompanied by the formation of pus in the anterior chamber; the pus is usually sterile on culture. Most of these ulcers on healing leave a nebula which for many months tends to get fainter, but unless very small, some permanent opacity is left, and if this lies in the pupillary region, impairment of sight necessarily follows.

In the *treatment* of simple small ulcers the use of atropine with warm bathing, a protective shade, and attention to the general health is sufficient. The more chronic and severe ones in addition require cauterising: if the base of the ulcer is necrotic, it should be curetted before cauterising. Hot fomentations, or dry heat applied by means of salt bags, are useful. In some cases of ulcers with hypopyon, where the pus increases in amount instead of being absorbed, it is advisable to let it out by a corneal incision. Cauterisation is performed by dropping a 2 per cent. solution of cocaine hydrochlor. into the eye, drying the area to be cauterised with blotting paper to prevent the acid from flowing freely over the cornea, and then applying 90 per cent. carbolic acid on a match stalk; irrigation afterwards is not necessary, but atropine should be instilled.

It may here be stated that atropine has three great values in ocular diseases. In the first place, it prevents all intra-ocular movements, such as the constant contraction and dilatation of the pupil, and the continual contractions of the ciliary muscle; it acts in fact much like a splint does to a wounded limb—it puts the eye at rest. Secondly, by dilating the pupil widely it withdraws the posterior surface of the iris from contact with the lens, and so prevents adhesions forming in iritis, etc. Thirdly, it has an emollient action.

## Interstitial Keratitis.

This is a lesion primarily of the substantia propria of the cornea, and it is upon this structure that the brunt of the disease falls, but in cases of any severity the iris, ciliary body, and even the choroid, later become involved.

This term has come to be used in a specific sense to indicate a disease which runs a definite clinical course; it is always due to syphilis, and in all but the rarest instances to congenital syphilis. The period of life between the ages of seven and seventeen includes much the largest number of cases, but it is by no means rare to see the disease in those outside these limits. It is commoner in girls than boys, and, like other manifestations of congenital syphilis, tends to occur in the elder children of a family. If the child is thoroughly examined other manifestations of congenital syphilis are usually found. Hutchinson's teeth are common, and it is probable that no individual with Hutchinson's teeth goes through life without developing interstitial keratitis. Frontal bosses, a depressed bridge to the nose, scars at the angles of the mouth, a muddy skin and deafness, are common; and if the child is stripped, curved tibiæ, tibial nodes, and Clutton's joints are often seen. It is by no means uncommon to find fluid in the knee joints when the mother has stated that there is nothing wrong, no doubt from the fact that, the condition being painless, the child has not complained.

The disease starts as a diffuse grey infiltration at the margin of the cornea, or as a scattered speckly infiltration. This infiltration gradually spreads till

the whole cornea has a milky appearance. One eye only is as a rule affected at first, but the second eye never escapes. General injection of the eye is present. After a week or so, vascularisation of the previously avascular cornea begins, and in some cases is so profuse as to give the whole cornea a salmon pink colour. During this stage the deeper parts of the eye are more or less involved. After a few weeks resolution commences, and in a case of moderate severity the active disease has subsided and the eye is almost white at the end of three months. There is, however, left a marked diffuse opacity of the cornea, owing to the round-celled infiltration which has taken place, and the presence of the blood-vessels. Except in a very few, permanent opacities remain, but the process of clearing goes on for a number of years. Owing to the softening of the coats, stretching takes place, and the attack leaves the eye with a varying degree of myopia. Both eyes are always attacked, sometimes with a considerable interval between; no sort of treatment, however vigorous, will prevent the onset in the second eye. Ulceration of the cornea is of the rarest occurrence, and recurrence does not take place.

FIG. 188.—Diagram to show course of new vessels (A) derived from the anterior ciliary arteries, which vascularise the cornea in interstitial keratitis.

The *treatment* should be generally hygienic—iron if anæmia exists, and some form of antisyphilitic treatment, although this does not have any influence on the course of the disease. Locally atropine must be used freely, and in the acute stage fomentations and dry heat are useful.

The presence of the residual nebulæ is often a help in after-life as evidence of the existence of congenital syphilis; they must, however, be distinguished from the nebulæ left after corneal ulcers. The following table will assist in differentiating the two conditions:—

| *Nebulæ left after Interstitial Keratitis.* | *Nebulæ left after Corneal Ulcers.* |
|---|---|
| 1. Always bilateral. | 1. May be bilateral. |
| 2. Irregularly diffuse throughout the cornea. | 2. Discrete, but may be multiple. |
| 3. Residual vessels deep and straight in parallel leashes (Figs. 188 and 189). | 3. Residual vessels superficial and branching dendritically (Fig. 189). |
| 4. Evidence of past iritis or choroiditis is common. | 4. Evidence of past iritis or choroiditis is rare. |

**Keratitis punctata** is not a disease in itself; it is, however, an important indication that the ciliary body is involved. It shows itself by the presence of small white or pigmented spots of various sizes on the back of the cornea (Fig. 190). They are composed of a collection of inflammatory cells. They have sharp edges, and so are distinguished from spots of infiltration in the substance of the cornea.

**Conical cornea** is what its name implies. It is an acquired condition, the

cause being unknown. It is generally developed during the second or third decade, and is commoner in women; it is usually bilateral. The apex of the cone is always a little to one side of the centre of the cornea. Vision is greatly impaired, but improvement may be brought about by suitably planned linear cauterisation of the cornea.

**Scleritis** or **Episcleritis** is a chronic inflammation of the sclerotic or the episcleral tissues in proximity to the cornea, and, in the absence of any knowledge as to its cause, it is often attributed to rheumatism. It may involve a localised patch, or may occur as a diffuse area surrounding the cornea. Middle-aged women are most often attacked. There is a dull red or purple coloured area of infiltration which lasts for weeks or months, improving and recurring, getting well over one area only to appear at another spot. An opacity of the adjacent cornea not infrequently develops, to which the name *sclerosing keratitis* is applied. Owing to its position over the ciliary body, this structure is sometimes involved by direct extension, as is shown by the presence of keratitis punctata. In some cases the coats of the eye are so weakened by long-continued inflammation that they bulge, producing a staphyloma. (A *staphyloma* is a localised bulging of any part of the eye, and is usually the result of ulceration.)

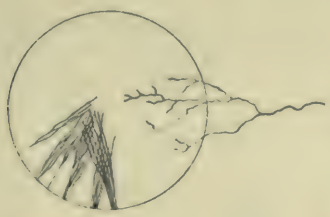


FIG. 189.—Diagram to show types of superficial (dendritic) and deep vessels in the cornea.

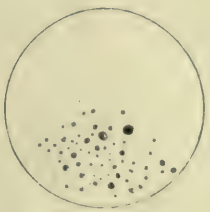


FIG. 190.—Punctate keratitis.

The *treatment* is tedious and unsatisfactory. If any obvious source of possible infection is present, such as pyorrhœa alveolaris, infection of air sinuses, multiple boils, or marked intestinal stasis, nothing but good will come of its treatment. Atropine is of some value, and alternating dry and moist heat give relief. Where a prominent lump is present, the conjunctiva may be dissected up from over it, and the nodule, which will be found to be in part composed of a curious gelatinous material, may be curetted and treated with pure phenol. This treatment will relieve the pain, which is often troublesome at night.

## DISEASES OF THE IRIS AND CILIARY BODY.

The reactions of the pupils to light and with convergence are of the highest importance. Normally both pupils contract in association with convergence of the eyes when light is thrown into them, and though light may be thrown into one eye only, both pupils contract (consensual contraction); this is because of the close connexion of the two third nerve nuclei in the mid-brain

The paths of the reflex arc concerned in contraction of the pupil are—
*afferent:* retina, optic nerve, optic chiasma, optic tract, mid-brain nuclei;
*efferent:* both third nerve nuclei (even though light is thrown into one eye only), third nerve, sphincter pupillæ.

Let us consider the effect on the pupil reactions of certain localised lesions.

*A lesion at A* (Fig. 191).—If light be thrown into the left eye there is no contraction of either pupil, for no impulse reaches the mid-brain, but if light be thrown into the right eye *both* pupils contract owing to the close connexion of the third nerve nuclei. *A lesion at B* (Fig. 191).—In this case neither eye is blind, consequently the pupils will contract, whichever eye receives the light stimulus, but if precautions be taken to impinge a ray of light on the blind half only of the retina, no afferent impulse reaches the mid-brain, and the pupil does not contract (Wernicke's pupil reaction). *A lesion at C* (Fig. 191).—In this case the left pupil will not contract under any circumstances, for the efferent impulse to it is completely blocked. The afferent impulse, however, from both eyes is intact, and consequently the right pupil will contract whether light be thrown into it or into the left eye. If a pupil contracts on throwing light into the eye, that eye certainly is not blind although the vision may be defective; the converse of this is not necessarily true. If there is a lesion of the occipital cortex producing hemianopia, the pupil contracts, even though the retina corresponding with the blind half of the visual field is stimulated, for the necessary reflex arcs are not interfered with (*cf.* Wernicke's pupil reaction). This reaction is of value at times in deciding whether a homonymous hemianopia is due to a lesion behind the mid-brain or in front of it.

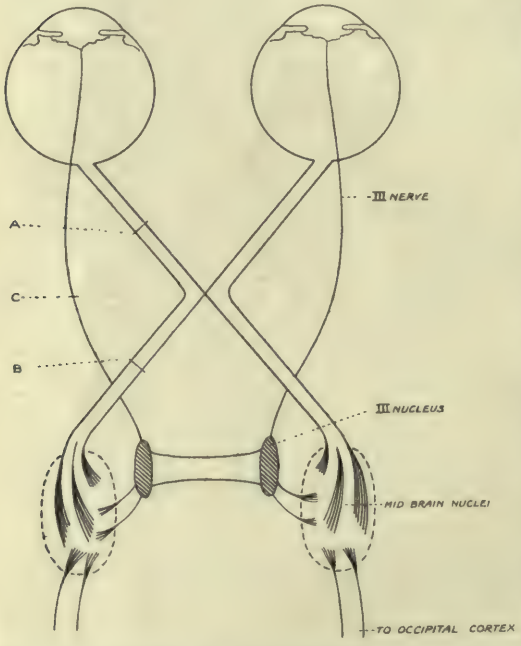



FIG. 191.—Diagram for consideration of the effects upon the reaction of the pupils to light produced by localised lesions of the reflex arc.

In about 11 per cent. of normal individuals an obvious inequality of the pupils exists. The pupils get smaller with age and are contracted during sleep. Any congestion of the eye, by producing a congestion of the vessels of the iris, causes the pupil to be somewhat contracted. The Argyll Robertson pupil is one which contracts with convergence, but does not contract to light stimulus.

**Iritis** frequently occurs as an incident in severe diseases of the eye, *e.g.*, interstitial keratitis, panophthalmitis, etc., but the two chief causes of a primary iritis are gonorrhœa and syphilis. Gonorrhœal iritis implies the existence of a gonorrhœal septicæmia, and is seldom seen in the absence of gonorrhœal arthritis; hence this form of iritis was often called rheumatic. Iritis as a complication of rheumatic fever does not occur.

Just as gonorrhœal arthritis is much more frequent in men than in women, so also is gonorrhœal iritis. The latter starts at a time when the gonorrhœal

arthritis is recent, usually within three months of infection, but recurrences of it, with or without urethritis or arthritis, are very common.

In addition to the ordinary signs of iritis (*vide infra*), the anterior chamber is sometimes filled with a yellowish gelatinous-looking exudate which is characteristic of this form of the disease.

**Syphilitic iritis.** Iritis occurring in an infant less than a year old is due to congenital syphilis, and in nine cases out of ten the child is a girl: it will be remembered that interstitial keratitis also is more common in girls, but not to so preponderating a degree.

When iritis develops in acquired syphilis it usually does so within three or four months of infection, and often exhibits buff-coloured nodules on the pupillary margin of the iris. The general signs of iritis are—a deep pink flush surrounding the cornea, contracted pupil, muddy discoloration of the iris, adhesions of the iris to the underlying lens (posterior synechiæ; these are best seen after the use of a mydriatic), and in cases of some standing new visible vessels are formed on the surface of the iris.

*Treatment.*—Any general cause, such as syphilis, must be treated. Locally the chief indication is to prevent the iris from becoming adherent to the lens by means of atropine. Leeches to the temple and moist and dry heat applied over the closed lids are of value. If extensive iridic adhesions form, an iridectomy may become necessary to prevent the development of secondary glaucoma (Fig. 195). In general it may be said that the causes and treatment of *cyclitis* are the same as those of iritis, for it is in direct anatomical continuity with the iris. There is, however, one sign which is taken as the hall-mark of cyclitis, and that is *the presence of keratitis punctata* (Fig. 190).

**Choroiditis or Chorio-retinitis.**—The choroid and the retina are in such intimate relationship that inflammation of one almost necessarily implies inflammation of the other, and, be it remembered, the function of the highly vascular choroid is to maintain the nutrition of the outer layers (the rods and cones) of the retina. The central retinal vessels only supply the inner retinal layers, and in some animals no retinal vessels exist. A prominent, but by no means the only cause of chorio-retinitis, is syphilis. The symptoms are very misty vision, sometimes of sudden onset, and complete absence of pain. If examined by the ophthalmoscope in the acute stage, no clear view is obtained owing to exudate into the vitreous; later, when the inflammatory process has subsided, one or several or many spots or small areas are seen, which are pale or white from destruction of the choroid and exposure of the underlying sclerotic. These areas are surrounded by masses of pigment, which proliferates and becomes irregularly distributed amongst the tissues whenever inflammation of the choroid takes place.

**Panophthalmitis** is an acute infection of all the tissues of the eyeball which results most often from infection following a perforating wound. Symptoms usually arise within forty-eight hours. The conjunctiva becomes injected and œdematous (chemosis), the cornea hazy, the pupil contracted and immobile, and a dull greenish haze appears in the pupillary area from purulent infiltration of the vitreous, the temperature is raised, there is intense pain in the eye, movements become impossible, and proptosis occurs. If nothing is done pus forms, the eye becomes an abscess cavity, and the pus ultimately bursts through its coats.

The only *treatment* is evisceration of the eye. The subarachnoid space of the brain is continued right up to the back of the eyeball; consequently when the nerve is cut across, this space is necessarily opened up, and in the case under consideration, if the eye be excised, there is a slight danger of meningitis.

It is better, therefore, to cut away the front of the globe and scrape away the contents with a sharp spoon, leaving a portion of the sclerotic behind and the nerve intact (evisceration of the eye).

## Diseases of the Lens.

There is only one disease of the lens of any common importance, and that is cataract, but of cataract there are many varieties. By a long way the most important form is the so-called *senile* cataract; *congenital* cataracts are not rare; any wound of the lens gives rise to a *traumatic* cataract, and certain general and local diseases give rise to *secondary* cataracts.

**Senile cataract.**—The development of opacities in the lens must be looked upon as one of the normal penalties of advancing years, for over 80 per cent. of individuals over sixty years of age have some lenticular opacity. It will be seen how unwise and how unjustifiable it is to tell a patient that he has cataract, simply because a few striæ of opacity are present in the lens. When, however, these opacities increase so as to obstruct vision seriously, it is proper to say that incipient cataract is present.

Cataract is diagnosed on examination of the lens after dilatation of the pupil in the dark room, by oblique illumination, and with the ophthalmoscope, when the opacities are readily seen. They are usually present in both eyes, though more advanced in one. A unilateral cataract, the other lens being clear, should always be looked upon with some suspicion. As age advances the lens normally becomes sclerosed and reflects more light than a lens in the young; this fact gives rise to a false appearance of opacity, and is responsible for a number of mistakes; such a lens, when examined by the ophthalmoscope, may quite well be perfectly transparent.

There are two types of senile opacity, but they are usually combined. In the one the opacity commences in the nucleus of the lens; in the other it commences as opaque striæ radiating from the periphery and advancing towards the centre. A cataract is mature when the process of opacification has involved the whole of the lens substance. A mature lens on operation is more easily removed entire than an immature one, and before the days of asepsis the leaving behind of some lens matter was so apt to favour suppuration, that patients were condemned to wait, although already almost blind, until the lens was mature. Immature lenses are now removed with impunity; this, however, should not be done unless the opacity does seriously obstruct vision.

A **traumatic cataract** results most usually from a penetrating wound of the eye which has punctured the lens capsule. Within a few hours of perforation the lens begins to absorb aqueous, and to become swollen and opaque.

The commonest form of *congenital cataract* is the lamellar. This is developed during the time the lens is being laid down in superimposed layers; some few of these layers, instead of being transparent, are opaque, and afterwards the normal process of laying down of transparent tissue is continued. The result is that an opaque centre becomes included within an otherwise transparent lens. The central opaque portion varies in every degree as regards size and density. The lens is of epiblastic origin, and this form of cataract is very commonly associated with defects of two other epiblastic structures, the teeth and brain. Thus the enamel of the teeth is often very deficient, and the patients are frequently the subjects of fits.

The only other type of cataract that need be considered is the *secondary cataract*.

There are a number of diseases of the eye which so disturb its nutrition that

the lens becomes opaque; such are cyclitis, detached retina, sympathetic ophthalmitis.

It is clearly of great importance to recognise that a particular cataract is, for instance, the direct result of a detachment of the retina, for not only will no advantage be gained by removing the lens, but the eye might well be lost in the process.

The points which suggest that the cataract is the result of other local disease are its presence on one side only, any evidence of posterior synechiæ, punctate keratitis, loss of pupil reflex, a soft eye or a hard eye, a dirty yellow colour of the cataract and faulty projection of light. With regard to this last, it should be remembered that with the eyelids closed there is no difficulty in distinguishing light from darkness; the light readily passes through all the tissues of the lid. So also, no cataract is so dense as to prevent light passing through it to the retina and causing contraction of the pupil; thus perception of light is always present. Further, the patient should readily tell from which direction a beam of light reflected into the eye by means of an ophthalmoscopic mirror is coming; this is called testing for projection of light. It is clear that if the retina is detached over its lower half, when light is projected into the eye from above it will not be seen. If then the cataract is a secondary one, it is a matter for especially careful consideration as to whether any advantage will be gained by removing it.

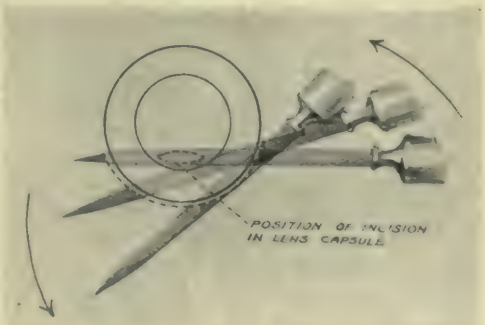



FIG. 192.—Diagram illustrating the method of making the corneal section and incising the lens capsule in cataract extraction. The eye is depicted as looked at from above, and therefore the imaginary watch dial will appear upside down to surgeon and reader.

**Treatment of cataract.**—There is only one treatment for the relief of cataract, and that is its removal; there are, however, two entirely different methods of effecting this. In young patients in whom no marked sclerosis of the lens has taken place it is got rid of by absorption after needling. The pupil being fully dilated, a needle is thrust through the cornea and made to lacerate the anterior lens capsule and to break up the anterior layers of the lens. After a few days the partly-disintegrated lens will be found to be coming forward as a flocculent white mass into the anterior chamber, and in the course of a few weeks this will be absorbed. A few weeks later the posterior lens capsule is incised, and so a clear unobstructed passage to the retina for light is obtained. As a rough guide it may be said that this method may be used up to the age of thirty-five.

The second method, applicable to senile cataract, is to remove the lens entire at one operation through a large incision. There are a number of modifications, but one method only need be described. The pupil is fully dilated by means of homatropine, the eye cocainised, and a good light ensured. The patient lies flat, the surgeon standing behind his head. A speculum is now inserted and the conjunctival sac irrigated with some simple lotion. If it is the right eye which is to be operated upon, a grip of the conjunctiva is taken with forceps held in the left hand, at six o'clock on an imaginary watch dial, and the patient told to look down. A Græfe's knife is now taken in the

right hand and entered just behind the limbus at ten o'clock. As soon as its point has got beyond the pupillary edge of the iris it is made to dip, so as to incise the anterior lens capsule, and is pushed on until it has to be raised so as to clear the iris on the opposite side. It is then pushed onwards so as to make a counter-puncture at two o'clock. So soon as this is accomplished, the point of the knife is made to complete the section in the manner indicated (Fig. 192). With a little practice it will be found that by the time the length of the blade has been used up the section will be completed; there are no sawing movements of the knife.

In effecting this section, although it has been described in stages, it is important that the progress of the knife should be forward all the time. If this is done the aqueous will not be lost until late, and no difficulty will arise from the iris falling over the knife and so being mutilated in cutting out. Having completed the section of the cornea, it will be found that the knife is still deep to the conjunctiva, and by to-and-fro movements a liberal flap of conjunctiva is fashioned as the knife cuts out. This flap forms an excellent covering for the wound when the operation is completed. Pressure is now made from below the cornea, and the lens is expressed through the hole in the capsule which has been made with the knife, through the dilated pupil, and so out through the wound. If the iris has become protruded it is now replaced with a fine flat spatula known as a repositor.

The next step is to grip a small portion of the root of the iris with iris forceps, pull it out through the incision, and snip it off. Having made sure that the iris is not engaged in the wound, the conjunctival flap is smoothed down over the incision, and the operation is complete.

The reason for the small button-hole iridectomy is, that in about 15 per cent. of cases, if this is not done, a prolapse of the iris is produced by some exertion or straining before the wound is sealed. If however this small hole is made, it acts as a safety valve through which the aqueous can escape without prolapsing the iris in front of it.

About a month later a needle is introduced to cut a hole in the remaining lens capsule, and so provide a clear passage to the retina for rays of light. A suitable lens about + 10 is afterwards supplied in the form of spectacles as a substitute for the lens which has been removed.

## Diseases of the Optic Nerve.

It need hardly be pointed out, seeing that the optic nerve is composed entirely of fibres coming from the retina, that any disease of the latter will affect the nerve.

The most important of the diseases of the optic nerve is papillœdema which, as its name implies, is an œdema of the nerve head (Plate 3, Fig. 4).

As has already been stated, the cerebral subarachnoid space is directly continuous along the optic nerve right up to the back of the globe. It will be realised that the central retinal artery and vein have to traverse this space in passing from their origin in the orbit to the centre of the optic nerve (Fig. 193). If then increased intracranial pressure exists, these two vessels will be subjected to it as they traverse this space. Of these two vessels, however, the artery is thick-walled and contains blood at a pressure of about 80 mm. of Hg, whereas the vein is thin-walled and contains blood at a pressure of about 25 mm. Hg. It follows that the inflow of blood into the eye will not be interfered with, whilst the outflow in the vein will be obstructed, and a mechanically-produced œdema of the nerve head results.

Thus papillœdema comes to be an expression of increased intracranial pressure, as is well seen in cerebral tumours. Ophthalmoscopically this shows itself as a great blurring of the disc edges, prominence of the disc, engorgement of the retinal veins, hæmorrhages on and around the disc, and areas of exudate which in places surround and obscure the vessels (Plate 3, Fig. 4).

**Optic atrophy** is of two kinds—primary and secondary.

The *secondary* type results from diseases of the retina or as a sequel to papillœdema. The disc is opaque white, the edges are blurred, and the vessels partly obscured and diminished in size (Plate 3, Fig. 5).

**Primary optic atrophy** is best seen as the result of a degenerative process, as in tabes dorsalis or general paralysis. In this case the disc edges are very sharp, the disc is grey, and the lamina cribrosa exposed; the vessels are of full size.

**Retrobulbar neuritis** implies an inflammation of that part of the optic nerve which is outside the eyeball. It results from inflammations in the orbit, and occurs in disseminate sclerosis and as a result of excessive smoking. The pupil contracts sluggishly to light, and its contraction is not maintained; there is great loss of vision, sometimes pain on movements of the eye, and but little ophthalmoscopic change. Recovery with restoration of function usually takes place.

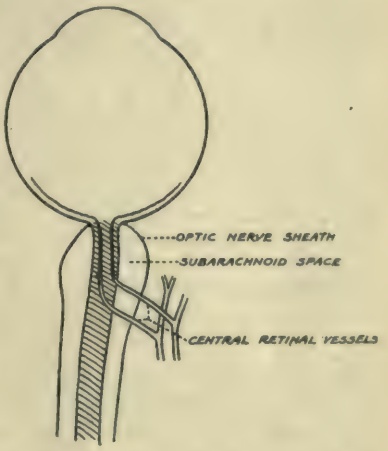



FIG. 193.—Diagram to illustrate the manner in which the central retinal vessels are exposed to an increased intra-cranial pressure with a consequent production of papillœdema.

### DISEASES OF THE RETINA.

In some conditions the retina is involved so much more extensively than the underlying choroid that the term retinitis may legitimately be applied. **Retinitis** is associated with many general diseases, and is in large measure characteristic in each case. The chief diseases in which it occurs are nephritis, diabetes, leukæmia, pernicious anæmia, syphilis, arterio-sclerosis, and infective endocarditis. The most important of these is nephritis. In this condition patches of white exudate are developed over the central regions of the retina around the disc and macula. In the macular region the exudate often takes the form of bright white spots arranged in a radiating manner and so forming a star-like figure (Plate 3, Fig. 3). Other soft-edged cotton-wool-like patches occur distributed irregularly around; retinal hæmorrhages are usually present. Patients seldom live for more than two years after the development of renal retinitis.

## Detachment of the Retina.

Without wishing to be hypercritical, it may be said that detachment of the retina never occurs, and this for two reasons. The retina is developed as a hollow outgrowth from the primitive fore-brain, this outgrowth having a bulbous extremity; this extremity later becomes invaginated so as to form a cup with an inner and outer layer. From the inner layer of the cup all the tissues of the retina are developed except its pigment epithelial layer, and this, and this alone, is formed from the outer layer of the cup. The space between

these two layers, which is potential only when development is complete, still persists in the adult, as is easily demonstrated in the post-mortem room, and this is the line of cleavage in a retinal detachment, so that the retina, never having been attached to the pigment epithelial layer, cannot become detached; and further it will be seen that at most it is only a portion of the retina which is "detached," the pigment epithelium remaining *in situ*. With this reservation let it be said that detachment of the retina may result from an injury, from shrinking of vitreous exudates, and from a sarcoma of the choroid. It is one of the complications greatly to be feared in high myopia, and occurs more commonly than is generally known in severe renal retinitis, especially in cases associated with pregnancy. The condition is diagnosed by the ophthalmoscope, the retina being seen bulging forwards into the vitreous (Plate 3, Fig. 6).

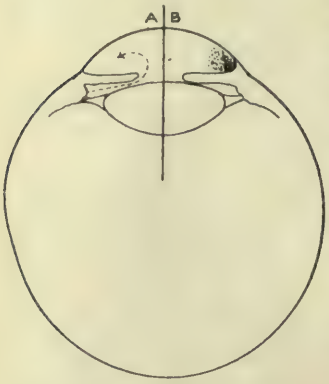



FIG. 194.—Diagram to show—
A. The normal course of the circulation of the aqueous.
B. Obstruction to the outflow of the aqueous produced by inflammatory exudate in the angle of the anterior chamber.

*Treatment* is by complete rest in bed, subconjunctival injections of hypertonic saline or sodium citrate solutions, or by cautery puncture of the coats over the site of detachment, so as to allow of the escape of the subretinal fluid.

## Glaucoma.

This is a disease which is associated with an increase of intra-ocular tension, to which most of the symptoms and signs can be referred. Normally the aqueous is secreted by a number of tubular glands which exist in the ciliary body, and is excreted at the angle of the anterior chamber into the spaces of Fontana and the canal of Schlem (A, Fig. 194). If this circulatory system becomes obstructed in any part, increase of intra-ocular tension results. The chief predisposing factors are a small eye, a large lens, and an acute angle resulting from a shallow anterior chamber (A, Fig. 195). These conditions exist in hypermetropic eyes in patients of advancing years, where the increase in size of the lens has reduced the circumlental space, and rendered the anterior chamber shallow. Besides these, certain diseases of the eye may result in obstruction to the intra-ocular circulation; *e.g.*, if the pupillary margin of the iris is completely bound down to the lens, the aqueous is unable to get through into the anterior chamber, the iris is bulged forward by it, and so the angle becomes secondarily narrowed (B, Fig. 195). Or, again, the angle may become choked by an accumulation of inflammatory cells, as in cyclitis (B, Fig. 194).

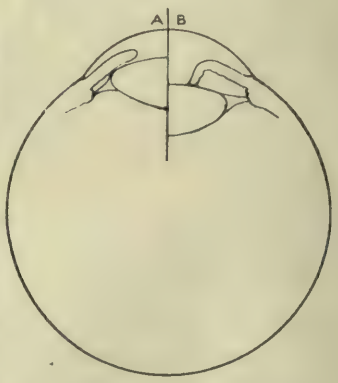



FIG. 195.—Diagram to show—
A. Outflow of aqueous obstructed by a shallow anterior chamber. B. Outflow of aqueous obstructed by adhesion of the pupillary margin of the iris to the lens.

The *symptoms* of chronic glaucoma are—progressive failure of sight, increasing difficulty with accommodation, attacks of obscuration of vision, and the presence of rainbow-coloured haloes around lights; these are due to œdema of the cornea, and may be imitated by looking at a light through a glass which has been breathed upon. The objective signs are—cupping of the optic disc (Plate 3, Fig. 2), increase of intra-ocular tension, reduction of the fields of vision, especially to the upper nasal side (Fig. 181), engorgement of the anterior ciliary veins, and pulsation of the retinal arteries. In this form of the disease all inflammatory signs are absent; it may, however, culminate at any time in acute glaucoma. In this event there is great loss of sight, so that light perception only may remain, great pain in the eye, and tenderness on palpation; the cornea becomes œdematous, the pupil semi-dilated, oval, and inactive, and the intra-ocular tension greatly raised, *e.g.*, 80 mm. Hg. Vomiting may be so prominent a symptom that the attack is attributed to gastric disturbance, with most disastrous results for the eye. In a few cases, if nothing is done, the eye may gradually recover, but subsequent attacks are inevitable, with blindness as a consequence.

The chief condition with which acute glaucoma may be confused is acute iritis, and, as the treatment of the one is the worst possible for the other, it is very important to differentiate them. The following points will usually be sufficient:—

| *Acute Iritis.* | *Acute Glaucoma.* |
|---|---|
| Occurs at any age, frequently in young adults. | Usually over forty-five. |
| Œdema of the cornea slight. | Œdema of the cornea marked. |
| Pupil contracted. | Pupil semi-dilated, oval, inactive. |
| Tension normal. | Tension greatly raised. |
| Loss of sight comparatively slight. | Sight very greatly impaired. |
| Other eye normal, or shows old posterior synechiæ. | Other eye often the subject of chronic glaucoma. |
| *Treatment:* Atropine imperative. | Atropine inadmissible. |

*Treatment.*—All treatment of glaucoma is aimed at the restoration of the free exit of the aqueous from the eye, so as to prevent the persistence of the increased intra-ocular tension. In some cases eserine drops, grs. ij. ad ʒj., night and morning, will keep the disease in check, by contracting the pupil and so preventing the base of the iris from obstructing the angle of the anterior chamber, and if, under this treatment, rainbow rings are prevented, and the visual fields can be shown to be undergoing no further reduction, it may be continued. If this line is adopted the patient must be kept under particularly careful observation. The best treatment, however, is operative by trephining. A curved conjunctival incision (Fig. 196) is made above, and the central part of the flap is dissected right down to the corneal margin.

When the cornea is reached the dissection is continued for a short distance, about 1 mm., into its substance. The flap is now held down over the cornea, and a small disc of tissue is removed by means of a 1½-mm. trephine at the junction of the sclerotic with the cornea, one half of the disc being composed of sclerotic and one half of cornea (Fig. 196). By this means the anterior chamber is made to communicate directly with the subconjunctival tissue spaces (Fig. 197). As soon as the disc is removed the aqueous escapes and protrudes a knuckle of the base of the iris through the hole. This is snipped off with scissors, and the iris then falls back into position. The conjunctival flap is replaced and fixed in position by two fine silk stitches. The aqueous now escapes freely into the subconjunctival tissues, which can be seen to be œdematous in consequence ; increase of tension is relieved and prevented from recurring.

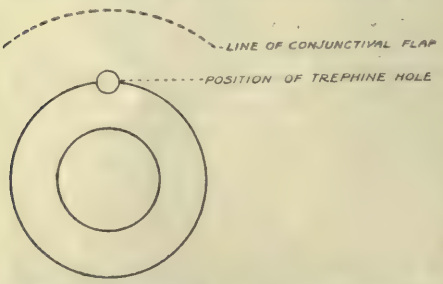



FIG. 196.—Diagram to show the positions of the conjunctival incision and of the trephine hole in the operation for glaucoma.

This operation is not suitable for acute glaucoma, an iridectomy being preferable. When glaucoma results from complete tying down of the iris to the lens an iridectomy will ensure a cure.

**Retinitis pigmentosa** is a congenital and hereditary disease of very slow progress. It is a degeneration of the retina associated with a pale, waxy-looking disc, reduction in size of the vessels, and the development of lace-like pigment in the retina which frequently ensheathes portions of the veins. It is associated with inability to see so soon as it becomes dusk. There is no treatment which is of any avail.

## Occlusion of the Central Retinal Artery.

This may come about in two ways : (1) by the lodgment of an embolus, as in infective endocarditis ; (2) by thrombosis in an artery which is already the seat of arterio-sclerosis. In the former blindness is quite sudden in onset. On examination the arteries are seen to be very reduced in calibre, and the blood can be observed making its way slowly along the vessels and in broken columns, similar to the appearances which are present immediately after death. Sometimes the blood is broken up into a succession of small blocks of red cells with narrower intervals of plasma in between, an appearance to which the term " cattle truck " arrangement is applied. In some cases the direction of the blood flow is reversed in branches of the artery. In addition, the central part of the retina becomes œdematous and opaque, and undergoes coagulation necrosis ; the macula stands out as a bright cherry-red spot in the centre of an opaque white area. When thrombosis occurs the loss of vision is more gradual, the patient will always be found

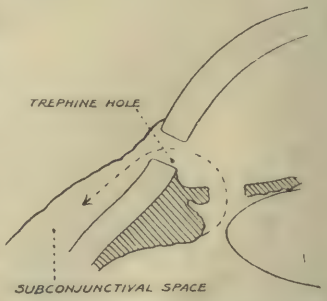



FIG. 197.—Diagram to show the course of the aqueous after the operation of trephining for glaucoma.

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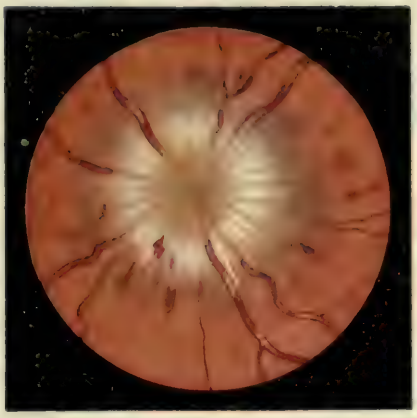

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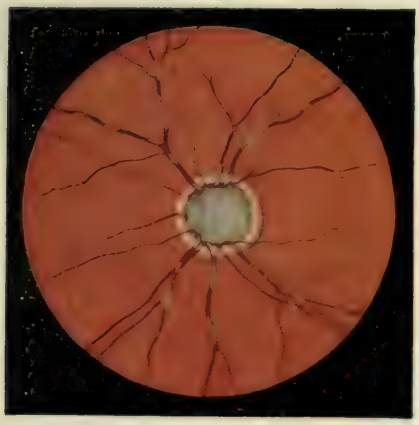

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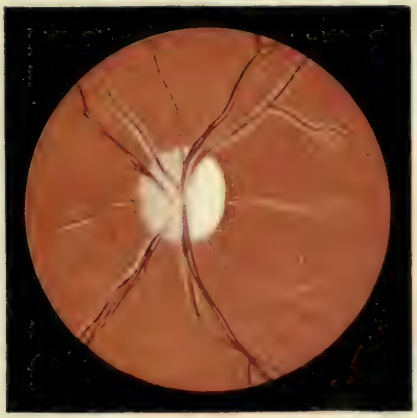

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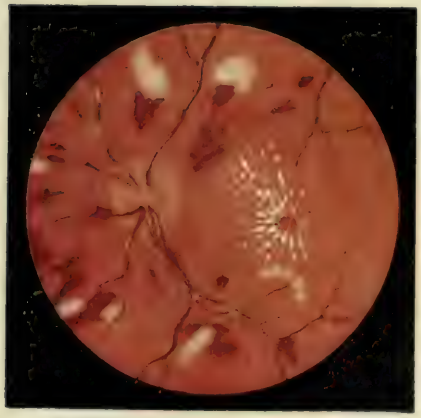

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FUNDUS OF THE EYE.

1. Normal fundus.
2. Cupping of the optic disc in glaucoma.
3. Albuminuric retinitis.
4. Papilloedema.
5. Post-papillitic atrophy of the optic disc.
6. Detachment of the retina in a myope.

to have arterio-sclerosis, and the cherry-red spot and central œdema are seldom seen.

Treatment in these cases is of no avail; the loss of vision is severe and permanent.

**Thrombosis of the central vein** of the retina is most frequently a result of angio-sclerosis. The veins become greatly engorged, dark, and tortuous. Profuse hæmorrhages occur over a wide area of the fundus. In course of time a collateral circulation is established, but not sufficiently early to avert irreparable damage to the retina. Secondary glaucoma is a not uncommon sequel.

The retinal arteries share in a general *arterio-sclerosis*, and seeing that these are the only vessels which are actually visible during life, and that under a magnification of fifteen diameters (direct ophthalmoscopy), an ophthalmoscopic examination in this condition is clearly of much interest and importance. The chief signs of retinal arterio-sclerosis are—(*a*) irregularity of lumen of the arteries; (*b*) compression and displacement of the veins where they are crossed by the thickened arteries; (*c*) a bright burnished appearance of the arteries of the second and third dimensions. Retinal hæmorrhages are often present, and later the development of exudates gives rise to arterio-sclerotic retinitis. This last condition has usually been mistaken for renal retinitis, owing to the fact that the kidneys share in the general disease, and albumen is frequently present in the urine, though often intermittently. It is, however, quite distinct, and carries a different prognosis.

## Injuries of the Eye.

A. *Non-penetrating.*

B. *Penetrating.*

A. **Non-penetrating injuries.**—These generally result from a blow with a blunt instrument or missile. The most common effects when intra-ocular damage occurs are—

1. A rupture of the iris, either of the sphincter or the base. In either case there is usually blood in the anterior chamber (hyphæma) and when the iris is torn away from its base a flattened pupil (iridodyalysis).

2. Dislocation of the lens. In this event the sight is much impaired, and owing to the fact that the iris is no longer supported behind by the lens, the anterior chamber is deep, and the iris itself is tremulous on movements of the eye. The edge of the dislocated lens can often be seen with the ophthalmoscope. In executions by hanging dislocation of the lens often occurs.

3. Rupture of the choroid. This occurs at the back of the eye, is roughly crescentic in shape and concentric with the disc. The sight is usually much impaired from damage done to the overlying nerve fibres.

B. **Penetrating injuries.**—These may be of the nature of a complete rupture of the eye, as by a piece of wood flying up whilst chopping, a perforation by a pen or the point of a knife or scissors, or by a minute fragment of metal which flies off when using a cold chisel, or during war.

*Treatment.*—If there is a clean perforation, no intra-ocular foreign body, and no part of the interior of the eye protruding, the wound should be cleaned, dried, touched with pure carbolic acid, and a conjunctival flap then sewn over. If iris or ciliary body is protruding, the same cleaning and cauterisation should be practised. The iris should then be freed, *pulled a little further through the wound* and snipped off. If done in this way, so soon as the iris is cut away, the cut edges spring back into the anterior chamber, and are thus completely freed from the wound. A conjunctival flap is again sewn over. If

an intra-ocular foreign body is present and is visible in the front of the eye, it can be removed by forceps after a corneal incision; if, however, it is in the vitreous chamber, it can only be removed if it is composed of magnetic iron or steel. In these circumstances it is best in most cases to drag the fragment into the anterior chamber, round the edge of the lens, by means of a giant ring magnet, and then to remove it from this position by means of a small hand magnet, after a corneal incision.

There is a special danger associated with penetrating wounds of the eye, viz., the development of a very severe form of irido-cyclitis in the opposite uninjured eye, a condition known as *sympathetic ophthalmitis*. Wounds which involve the ciliary region are more especially likely to produce it.

Sympathetic ophthalmitis rarely develops before eighteen days after the injury, but it may occur after a much longer interval. It is characterised by the slow development of iritis, with a plastic exudate into the pupil, punctate keratitis, exudate into the vitreous, and spots of choroiditis scattered freely over the fundus. In many cases the eye shrinks and loses all useful vision.

*Treatment.*—The most important treatment is preventive. If, at the end of eighteen days or earlier, it seems probable that an eye which is the subject of a penetrating injury will ultimately be of little or no use, it should be removed, and especially if punctate keratitis is present and the eye is soft. If, however, sympathetic disease is already declared, and the injured eye shows good prospect of being really useful, and is already improving, it should in general be spared.

The treatment of the disease is by mercury or salicylate of soda, and locally by atropine, leeches, hot bathing alternated with dry heat, and dark glasses. Sympathetic ophthalmitis never occurs apart from a penetrating injury.

## Tumours.

**Intra-ocular.**—*Innocent.*—A *melanoma* appears in the posterior part of the choroid as a growth up to about three times the size of the disc, of a homogeneous blue-ointment colour; it is discovered on routine examination, gives rise to no symptoms, and has no more significance than a pigmented mole of the skin. It also occurs in the iris.

*Malignant.—Glioma:* This is a growth of the retina which occurs in children up to the age of seven. In 20 per cent. of cases it is bilateral. It gives rise to a greenish pupillary reflex which the parents often compare with that seen in a cat's eye. As it increases it grows back along the optic nerve; consequently when removing the eye the nerve should be divided as far back as possible. Dissemination occurs late, and if the whole growth is removed and the opposite eye is free a permanent cure results.

*Sarcoma* is a growth of the uveal tract, and is usually, therefore, pigmented. It occurs usually in adults over thirty years of age. In the early stage of its growth it gives rise to no symptoms unless it involves the yellow spot. After some time, however, as the retina becomes detached by the increasing growth behind it, the consequent loss of vision is noticed. Later on, as the growth comes to fill the eye to a greater extent, the vision is lost, and glaucoma ensues. It is sometimes exceedingly difficult to say whether a detachment of the retina is due to a sarcoma behind it, or to some less threatening cause. Dissemination occurs through the blood-stream, and if left, the growth bursts through the coats of the eye and invades the orbital tissues.

The only treatment is early removal of the eye. In some cases enlargement

of the liver, fluid in the peritoneal cavity, wasting, or melanuria will supply evidence of dissemination. If removed early the prognosis is better than with similar growths elsewhere.

Growths secondary to malignant tumours elsewhere occasionally appear in the eye.

**Orbital abscess** is caused by the spread of infection from the nose or surrounding air sinuses, periostitis of any of the bones of the orbit, erysipelas, or by pyæmia. The eye is proptosed, movements are much limited or entirely absent, chemosis of the conjunctiva may be great, sight may be lost from involvement of the optic nerve, pressure on the eyeball causes pain, and there is marked constitutional disturbance. Septic thrombosis of veins, spreading to the cavernous sinus, and cerebral abscess, are of sufficiently frequent occurrence to give rise to some anxiety in these cases.

The treatment is early incision and free drainage.

**Proptosis.**—It may be of help to enumerate under one head the chief conditions which give rise to this sign.

A. *Constitutional conditions :—*
1. Graves's disease.
2. Oxycephaly.
3. Hydrocephalus.
4. Hæmorrhage into the orbit in infantile scurvy.

B. *Diseases in the orbit :—*
1. Cellulitis or abscess.
2. Nævus.
3. Growths of the optic nerve (intra- or extra-dural).
4. Growths of the lachrymal gland.
5. Growths of the eye which have burst through the coats.
6. Secondary growths.

C. *Diseases of surrounding structures :—*
1. Exostoses of the frontal bone.
2. Growths starting in the ethmoid region, maxillary antrum, or pterygo-maxillary fossa.
3. Empyema or mucocele of the ethmoid sinuses or of the frontal sinus.
4. Arterio-venous aneurysm in the cavernous sinus.

**Enucleation of the eye.**—The points about this operation are to save all the conjunctiva, as it is this that is to line the socket afterwards; to be sure to remove the whole eye and not to leave a portion of the uveal tract behind, which afterwards might give rise to sympathetic ophthalmitis; and, if it is a clean case, to sew a glass globe into Tenon's capsule, so as to get a good movable stump, and one which will prevent the glass eye from sinking deeply into the orbit. The objection that the glass ball is extruded is quite unfounded if it be sewn in by means of one purse-string suture which takes up the cut muscles and Tenon's capsule, and another purse-string which takes up the conjunctiva only.

## Errors of Refraction and Accommodation.

The light percipient portion of the eye exists at the external layer of the retina (*rods and cones*), and it is necessary for perfect vision that images of external objects should be accurately focussed on this layer. Rays of light passing into the eye are refracted at the anterior surfaces of the cornea, lens, and

vitreous, and brought to a focus at a point varying with the refraction. The human eye, for the sake of simplicity, may be considered as represented by a convex lens of 23 mm. focus ; and the following laws regulating the passage of light through a convex lens will then be applicable to it. Rays of light passing through a convex lens (Fig. 198, L) parallel (P) to the principal axis (XX), and therefore coming from infinity, are brought to a focus at a point (Em.) (*principal focus*) varying inversely in distance to the convexity of the lens ; rays coming from a point (D) closer than infinity (*divergent rays*) are refracted further back (My.) from the lens than the focal point ; and rays coming from a point (C) beyond infinity (*convergent*) are focussed at H between the lens and its principal focus (Em.).

**Emmetropia.**—In an eye of normal refraction (*emmetropia*) with its accommodation relaxed, parallel rays (P) passing through the pupil will be focussed by the surfaces at a point (Em.) represented by the external surfaces of the rod and cone layer of the retina ; divergent rays (D) will be focussed behind the retina at My., and convergent rays (C) in front of the retina at H. In order to focus the divergent rays (D) upon the retina (Em.) it is necessary to increase the convexity of the lens and so shorten its focal length. This is done by accommodation, and a young emmetrope with normal accommodation should be able to focus on his retina all rays from parallel to divergent ones starting from a few inches in front of his cornea.

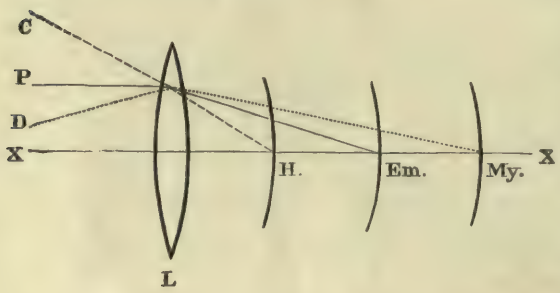



FIG. 198.—Diagram to illustrate errors of refraction. L. Convex lens. XX. Principal axis. D. Divergent ray. P. Parallel ray. C. Convergent ray. H., Em., and My. Position of retina in hypermetropic, emmetropic, and myopic eyes.

**Hypermetropia** is the condition in which with the eye at rest the retina (H) only receives certain convergent rays (C) ; parallel rays (P) and divergent rays (D) are refracted beyond the retina (H). This takes place owing to the distance between the cornea and the retina being too short, or from lessened convexity of the lens ; the usual cause is congenital shortness of the axis of the eye. Hypermetropes are obliged to accommodate for parallel rays, and still more for divergent ones. The treatment naturally is to increase the convexity of the lens artificially by giving a convex lens ; and by so doing parallel rays can be refracted on the retina, and then the ciliary muscle ought to be able to focus divergent rays on the retina. In children and young adults, to find out their hypermetropia it is often necessary to order atropine before testing the refraction, but in adults homatropine and cocaine drops applied twice just before examination are sufficient. The symptoms of hypermetropia are pain and discomfort on reading, congested eyelids and conjunctivæ, spasm and fibrillar twitchings of the lids, convergent strabismus, headache, and neuralgia. Hypermetropia is usually congenital, often hereditary, and is frequently associated with a flat-looking face, shallow orbits, and small eyes.

**Myopia** is the opposite condition to hypermetropia, and in it the retina (My.) only receives certain divergent rays (D). It is due as a rule to the axis of the eye being too long, or in some cases to the ciliary muscle rendering the lens too

convex (*spasm of accommodation*). The treatment, except in cases of spasm of accommodation, is to give concave glasses to allow parallel and divergent rays to fall on the retina. In low degrees of myopia it is only necessary to order glasses for distance, but in high degrees the full correction may be worn for everything, or a stronger pair for distance and a weaker for reading. In apparent myopia due to spasm of the ciliary muscle it is important to order atropine to find out the true refraction. Myopes often have the head elongated in the antero-posterior diameter, a long face, and large prominent eyes. Myopia is generally accompanied by a crescent at the outer side of the disc or by posterior staphyloma, and there may be secondary choroidal trouble, detachment of the retina, and vitreous opacities.

**Astigmatism** is the condition in which one or more of the refractive surfaces have not the same curvature in all directions. Astigmatism may be divided into—(1) *irregular*, in which there is a difference of refraction in the several parts of the same meridian due to changes in the lens and cornea, and (2) *regular*, where there is a difference in two meridians (*chief meridians*) at right angles to one another, and called those of maximum and minimum refraction. It is usually corneal (*static astigmatism*), but may be due to the action of the ciliary muscle (*dynamic astigmatism*). Regular astigmatism may be (*a*) *simple*, where one meridian is emmetropic and the other hypermetropic or myopic, and is then called simple hypermetropic or simple myopic astigmatism; (*b*) *compound*, where the chief meridians are unequally myopic (compound myopic astigmatism) or unequally hypermetropic (compound hypermetropic astigmatism); or (*c*) *mixed*, where one chief meridian is hypermetropic and the other myopic. Persistent headache is commonly met with in astigmatism. The treatment is by cylindrical glasses for simple astigmatism, and by cylindrical glasses in combination with sphericals for compound and mixed.

**Presbyopia.**—In the eyes of all persons from forty to forty-five years of age it is found that, owing to changes in the elasticity of the lens, the ciliary muscle begins perceptibly to lose its power of altering the convexity of the lens. The effect of this will be to prevent near objects being focussed on the retina at the usual reading distance; in order to counteract this condition and to aid the ciliary muscle it is necessary to prescribe convex glasses for reading. It has been found that the glass needed is about one dioptre for every five years after forty, and therefore an emmetrope forty-five years old needs + 1 D, one of fifty-five years + 3.

## Strabismus and Ocular Paralysis.

**Strabismus** (*squint*) is always present when the two eyes are not directed simultaneously towards the same object, and is usually accompanied at some time by double vision (*diplopia*). Strabismus occurs from over-action, weakness, or paralysis of one or more of the extrinsic ocular muscles. It is generally convergent or divergent, but may be upward or downward. It may be constant (*fixed*) or occasional (*periodic*), and though usually only one eye squints, yet sometimes both eyes may do so in turn (*alternating*). When the squinting eye follows its fellow normally in all its movements the squint is called *concomitant* in contra-distinction to *paralytic*. Diplopia is much more marked in paralytic than in concomitant squint. The non-squinting eye is called the *fixing* eye, and strabismus may be estimated by telling the patient to look at an object about two feet away with the fixing eye, and then taking the distance between the middle of the palpebral aperture and the middle of the cornea of the squinting eye (*primary squint*); on now making the squinting become the fixing eye the amount of deviation of the original fixing eye is taken (*secondary*

*squint*). In *paralytic* cases the secondary squint exceeds the primary, but it is equal to or less than the primary in *concomitant* squint.

*Convergent strabismus* (*internal squint*) is most commonly met with in hypermetropia, owing to the fact that the excessive accommodation necessitates a correspondingly great convergence ; but it may occur occasionally in myopia, and also follows division or paralysis of an external rectus.

*Divergent strabismus* (*external squint*) is caused from insufficiency of convergence power, and weakness of the internal recti, especially in myopia ; from defective vision of an eye, as in corneal nebulæ ; and from division or paralysis of an internal rectus.

The treatment of concomitant strabismus is by atropine, eserine, spectacles, prisms, and stereoscopic exercises. The operations that may be required are either tenotomy of the muscle of the affected side or advancement of the muscle of the opposite side. The treatment of paralytic strabismus is by constitutional remedies and galvanism of the affected muscle.

*Tenotomy of the internal rectus.*—Patient lying down on an operating table and under local or general anæsthesia ; operator standing in front and to the right-hand side. Introduce the spring speculum, and pinch up with a pair of fixation forceps the conjunctiva and subconjunctival tissue at the point of junction of the lower horizontal and inner vertical tangents of the cornea. Divide this fold, making the incision only large enough to admit the blunt points of the scissors, and then, passing the scissors through the incision, divide the capsule of Tenon. Pass the strabismus hook into the wound, directing its point backwards, and then turn the end of the hook upwards between the globe and the tendon, until its point is seen beneath the conjunctiva, at the upper border of the tendon. Introduce the scissors through the wound, and open the blades on either side of the tendon between the globe and the hook, and by one or two snips cut it through. Remove the hook and then reintroduce it to ascertain that the tendon is completely divided. A retention stitch should now be passed through the cut tendon and tied loosely to the conjunctiva close to the cornea to prevent the muscle from falling too far back and losing all attachment to the globe. The eyes should be bandaged for about twelve hours. The method is the same for the external rectus, but it must be remembered that the tendon is situated a little further back.

*Advancement of the external rectus.*—Patient prepared as for tenotomy ; the operator, however, stands behind the patient's head. After introducing the wire speculum between the eyelids, seize the conjunctiva about 2 mm. from the corneal margin over the centre of the insertion of the muscle. Divide the conjunctiva and subconjunctival tissue for about 10 mm. vertically and thus expose the tendon. Pass the tenotomy hook under the tendon and give it to an assistant to hold. Insert a small curved needle threaded with fine silk and held by a needle-holder through the lower margin of the muscle as far back as is necessary from the insertion of the muscle, and then pass another threaded needle in the same way through its upper margin. Now with a pair of scissors divide the muscular fibres parallel to the incision, and remove the hook. Cut off the piece of muscle adhering to the sclerotic. Now pass each needle (one above and the other below) through the episcleral tissue near the cornea and bring it out beneath and through the conjunctiva at the required distance in front. Tie both sutures tightly and then stitch together the edges of the conjunctival wound. Both eyes should be bandaged for a week and then the sutures removed.

**Ocular paralyses.**—*Complete paralysis of the third nerve* is characterised by complete ptosis ; external strabismus ; inability to move the eye completely

up, down, or in; crossed diplopia; moderate mydriasis and inactivity of the pupil to all the reflexes; and paralysis of accommodation. Any one of the muscles supplied by the third nerve may be separately paralysed, also the superior oblique (fourth nerve) and the external rectus (sixth nerve). *Paralysis of the external rectus* gives rise to internal strabismus, inability to move the eye outwards, and homonymous diplopia. It is the most common of the ocular palsies, probably from the long course of the sixth nerve. All the external ocular muscles may be paralysed at the same time (*ophthalmoplegia externa*).

The intra-ocular muscles are the pupillary (*sphincter pupillæ*) and the ciliary. The *pupillary* muscle may be affected by paralysis of the third or short ciliary nerves, producing medium mydriasis, and by paralysis of the cervical sympathetic or long ciliary nerves, producing partial myosis. The ciliary muscle may be paralysed (*cycloplegia*) by affections of the third or short ciliary nerves, usually in conjunction with paralysis of the pupillary muscle. It may be paralysed alone, as in diphtheria. In certain diseases, as locomotor ataxia, the pupil acts to accommodation, but not to light (*Argyll Robertson or spinal pupil*).

The treatment of ocular paralyses is chiefly constitutional. Many are of syphilitic origin, and require anti-syphilitic treatment; faradisation of the affected muscle may also be employed. In mydriasis and cycloplegia the use of eserine is indicated.

**Nystagmus** (*involuntary oscillations of the eyeball*) is generally binocular, and the movements of the eyes are usually horizontal or rotary; the movements cease during sleep. It occurs as a rule in early life, and is then due to defect of sight from corneal ulcer, etc., sometimes in adult life in patients with diseases of the nervous system, such as disseminated sclerosis, and in coal miners, in whom it is probably due to their position at work in diseased conditions which involve the semicircular canals, and as a hereditary condition.

In normal individuals nystagmoid movements of small excursion occur when looking to the extreme right or left, and especially if the object looked at is outside the field of binocular vision. Such movements have no significance.

# Section XI.

## FRACTURES.

**Definition.**—A fracture is a solution of continuity in bone, produced either by direct violence or by flexure or by torsion. This definition excludes two varieties of fracture in which there is not complete solution of continuity. *Fissured fractures* may occur in flat bones, such as the skull, without the fragments being completely separated and mobile upon each other. They also occur in long bones, the fissure being incomplete and running in the direction of the length of the bone.

When a fissure occurs in a bone which has been softened by disease such as rickets, the unbroken part of the bone may bend, so that there is deformity without a complete fracture. Such a fracture is called a *greenstick fracture.*

**Mode of production of fractures.**—It is usual to differentiate fractures by direct and by indirect violence. For example, a blow upon the skull causes a fissured fracture by direct violence, or a wheel passing over the tibia breaks it at the point of contact. On the other hand, a fall upon the hand may fracture the radius (Colles) or the lower end of the humerus or the clavicle—the force being transmitted up the limb and the fracture taking place at some weak spot. In many indirect fractures the break results from bending of the bone, in others it results from torsion. In fact, fractures may be likened to the breaking of a piece of wood by direct or by indirect violence. A direct blow upon the wood breaks it at the point of contact by a sudden bending strain. If, however, the wood is gradually bent across the knee, it breaks at its weakest point.

The actual site of the fracture and the resulting displacement of the fragments depend upon many circumstances, such as the direction of the force, the shape and architecture of the bone, the position of the limb at the moment, and the fixation of parts of the bone by muscles and ligaments.

Indirect violence may produce fractures by any of the following processes :—(1) Flexion, the bone being bent until it breaks at its weakest or least supported point; (2) torsion, the bone being twisted until a spiral fissure is produced running up the shaft; (3) cancellous bone may be crushed by pressure between adjacent bones, or between the bone above and the ground (for example, a fall upon the feet may crush either the os calcis or the astragalus); (4) a force transmitted across a joint may tear off a piece of bone to which a ligament is attached, as in Pott's fracture, when the internal malleolus of the tibia is torn off.

The action of the muscles is of considerable importance in the production of fractures, and in settling the displacement that will occur. Certain fractures are ascribed to muscular violence. These fall into three classes. In one group may be placed fractures of the patella and of the olecranon and coronoid processes of the ulna. In these the fractured bone is held by a powerful muscle and split by the opposing forces of some external violence and this muscle.

In the second group come those occasional cases of fracture of a long bone occurring during some violent movement. The most frequent example is

a fracture of the shaft of the humerus arising during the action of throwing. In this a very quick movement is carried out and stopped suddenly by muscular action. The fracture apparently results from a sudden arrest of movement in a limb possessing a considerable momentum.

Fractures of the neck of the femur in children have occurred from muscular violence—dancing and jumping being a usual cause. In these the fracture apparently results from a torsion strain acting upon the weak bone in the neighbourhood of the epiphysis of the head of the femur.

**Pathological fractures.**—A pathological fracture is one that is produced by slight violence, because the bone is weakened by some pathological cause. These are often called "spontaneous fractures," but this is a misnomer. Some force must always be a factor, even though it is a small one.

The causes of pathological fractures are the following :—

1. *Atrophy of bone.*—In senile atrophy the whole bone is lighter, the compact

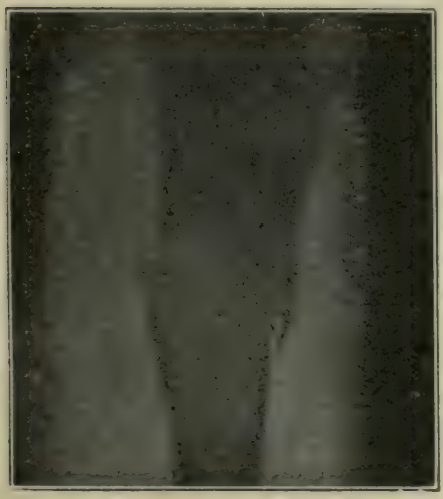


FIG. 199.—Fracture of humerus through a cyst.

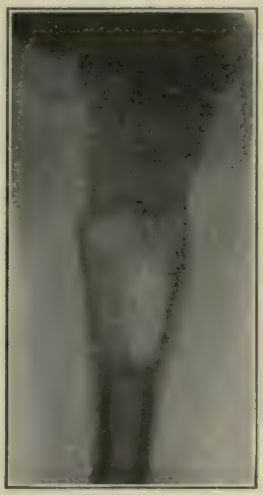


FIG. 200.—The same case as Fig. 199, showing union in one month.

tissue thinner, the medulla and the Haversian canals larger. As a consequence the bones of old people are fractured with greater ease than are those of a young adult. Simple disuse results in similar trophic changes. If disuse of a limb has involved also immobilisation, the atrophy is greater. Fixation of a limb in plaster of Paris rapidly induces atrophy, so that great care has to be taken in forcibly manipulating a limb which has been fixed in plaster. In atrophy from disuse alterations in the architecture of the bone take place, the regular lines of stress being less clearly visible in an X-ray photograph ; the bone becomes more uniform in consistency, with perhaps a mottled appearance, due to an irregular arrangement of the laminæ.

Paralyses of various sorts produce atrophy, perhaps partly from disuse, certainly partly as the result of trophic changes. In a paralysed limb a fracture is produced more easily than in its healthy fellow. In certain nervous diseases, particularly in tabes, general paralysis of the insane, and certain varieties of insanity, fractures occur from very slight violence. In tabes there is an actual diminution in the proportion of lime salts in the bones.

Besides these general causes of atrophy which affect the whole skeleton, or a limb or limb segment, local atrophy of bone may be produced by external pressure, for example, by an aneurysm or by a tumour which has pressed upon and eroded the bone until so little remains that a fracture may occur from very slight violence.

2. *Fragilitas ossium.*—This is a family disease, in which the bones are unduly fragile, because they are of an exceptionally light texture throughout. This condition may exist in a family for several generations. Numerous fractures occur, but if they are well treated they unite soundly and without deformity. There is no special liability to non-union.

3. *Fibrocystic disease.*—This condition causes a liability to fracture at the site of a cyst. Such cysts may be single, in which case they will often be discovered only when a fracture occurs through them. They may also be multiple, giving rise to the occurrence of multiple fractures and suggesting at first sight that the patient suffers from fragilitas ossium. In these cystic conditions the X-ray appearances are diagnostic, showing an expansion of the bone with absorption of the compact tissue by a cyst growing within it.

4. *New growths of bone.*—A fracture may occur through any variety of new growth. It is most common, however, where the new growth is endosteal, for example, in a myeloma, or secondary endosteal growth.

Pathological fractures are not very uncommon when secondary growths have resulted from carcinoma of the breast, of the prostate or of the thyroid gland.

5. *Osteomalacia.*—In true osteomalacia, spontaneous fractures are not so common as might be expected. This is probably due to the nature of the pathological changes in this disease. The framework of the bone in osteomalacia remains intact, but the lime salts are absorbed from it. As a consequence the bone becomes soft and elastic, bending rather than breaking.

6. *Rickets.*—Pathological fractures occur in rickets, but are not very common. This is possibly due to the fact that children with very active rickets, when the bones are soft, are not likely to get about much and run the risk of injury. In rickets also the pathological changes lead to bending of the bones rather than to fracture.

7. *Inflammatory conditions.*—Inflammatory conditions of the bones only give rise to pathological fractures when they result in absorption of such a proportion of the bone as very materially to lessen its strength. Tuberculous disease hardly ever produces a pathological fracture. In chronic osteomyelitis, with central sequestra, there is most often much formation of new periosteal bone. It is only in cases with extensive necrosis and little new bone formation that fracture is likely to take place.

In syphilis the changes again are most often of the nature of a hyperostosis. Occasionally, when a central gumma has produced rarefaction, fracture may occur. A few cases of pathological fracture have occurred in *osteitis deformans.*

8. *Hydatid cysts of bones.*—These are very uncommon in England. In countries in which they occur, however, they give rise to pathological fractures.

Separation of epiphyses occurs in certain pathological conditions without any external violence or with only very slight violence.

In acute septic epiphysitis, and in syphilitic epiphysitis, the separation occurs as a direct result of the inflammatory process. In scurvy rickets the separation may result from slight violence or may possibly be due to a hæmorrhage. In all these cases the separation really occurs through the cancellous bone at the end of the diaphysis, close to the epiphyseal cartilage.

**Varieties of fractures.**—Fractures are divided into simple and compound.

In the latter there is a wound of the skin and soft parts, reaching down to the fracture. A wound which does not extend to the fracture does not render the latter compound. In some cases a fracture which is originally simple becomes compound because of the separation of a slough which overlies it, or because an incision is made upon it. Such a fracture is secondarily compound.

Many varieties of fracture may be recognised according to the condition of the bone. In a complete fracture the bone is separated into at least two pieces which are mobile upon each other. The Greenstick fracture and fissured fracture, varieties of incomplete fracture, have already been mentioned.

As a rule, we may recognise the direction of a fracture of a long bone as transverse, oblique or spiral. When the bone is broken into more than two pieces it is said to be comminuted. Fractures are most apt to be comminuted when they are produced by crushing or by direct violence. In a fracture produced by direct violence there is often a single split on the side to which the violence is applied, from which two fissures radiate obliquely, upwards and downwards, to the opposite side, so that a central V-shaped piece of bone is separated (Butterfly fracture).

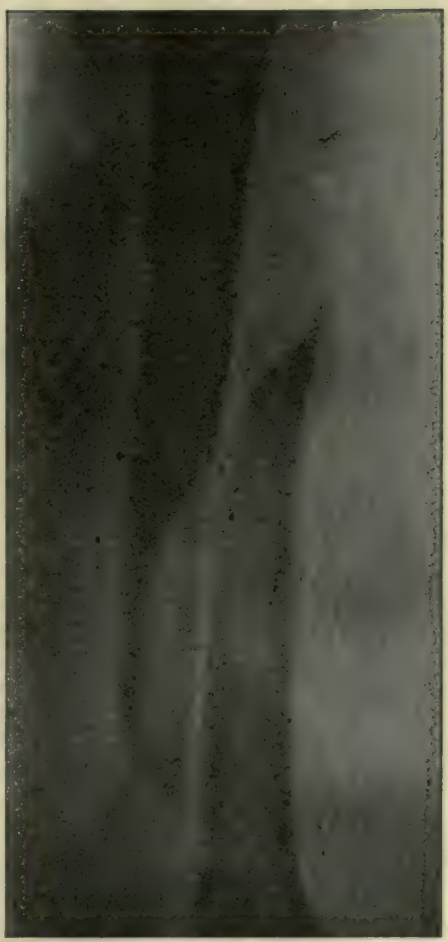


FIG. 201.—Spiral fracture. An X-ray photograph of the femur of a boy who had fallen out of a window.

**Displacement.**—The displacement of the fragments of the bone upon each other may be analysed into displacement in one or more of the following directions :—

(*a*) *Longitudinal*, that is, in the axis of the limb, the ends of the bone usually overlapping each other, with resulting shortening of the limb. Occasionally, however, the fragments may be pulled apart so that the limb is actually lengthened ; this is most likely to happen in a fracture of the humerus.

(*b*) *Lateral*, the lower fragment lying in front or behind, or on one or other side of the upper.

(*c*) *Angular*, the lower fragment making an angle forwards, backwards, or to one or other side with the upper.

(*d*) *Axial*, the lower fragment rotating on the upper, so that (for example, in a fracture of the femur) with the upper fragment in its correct position the lower fragment may be rotated out and produce severe eversion of the foot.

(*e*) *Impaction.*—Here the end of one fragment, or some part of it, is driven into the other fragment. Impaction most often occurs in a fracture near the end of the shaft of the bone. One edge of the fragment which includes the shaft is driven into the cancellous tissue of the other fragment. For example, in a Colles's fracture the posterior edge of the upper fragment is driven into the cancellous tissue of the lower fragment.

It is important to realise the way in which displacement of the fragments is produced, for upon the formation of a clear estimate of the forces producing displacement much of the success in the treatment of fractures depends. In most cases the actual force which produces the fracture is also chiefly concerned in the production of the displacement. This is true, for example, in a Colles's fracture, in the common fractures of the lower end of the humerus, and in Pott's fracture.

In some cases some other external force acting upon the limb after the fracture has occurred is the cause of displacement. This external force is generally the weight of the limb or the weight of the body. Thus, when the femur is fractured, the lower fragment, carrying with it the leg and foot, practically always falls into a position of external rotation as soon as the patient falls, or is laid upon the ground. If the tibia and fibula are fractured by direct violence the actual displacement may be settled by the way in which the patient falls—that is, by the way in which the body weight acts upon the fragments.

FIG. 202.—Fracture of neck of femur with comminution of the great trochanter due to impaction. (St. Bartholomew's Hospital Museum.)

The action of muscles is a third factor to be remembered in considering displacement. In a fractured femur the fragments practically always overlap because of the pull upon the longitudinally disposed muscles. In a fracture of the upper part of the radius the upper fragment is always strongly supinated by the biceps. In general, however, it may be said that the displacements produced by the pull of muscles are less important and more easily overcome than are those produced by external force.

**Examination and diagnosis of fracture.**—It is important that a fracture should be diagnosed without any more elaborate examination than is absolutely necessary. Careless handling may produce additional displacement or may render a simple fracture compound. Therefore when an injury has occurred, which may have resulted in a fracture, the patient should be disturbed and moved as little as possible until the diagnosis has been made.

The first step is the removal of clothing from the part. This should be carried out without moving the neighbouring joints, the clothing, if necessary, being cut. If possible, an exact account of the accident should first be obtained, the patient's symptoms (particularly the site of pain) being ascertained, and the nature of any disability felt.

In a gross fracture, such as one of the femur, the shock will be severe, the pain great, and the disability complete. The diagnosis will usually be evident from the physical signs. In other fractures, however, the physical signs may be very slight. This is particularly true of fractures of the small bones of

the hands and feet. The presence of localised pain and of inability to carry out certain active movements may be then of great importance.

The next step is a systematic inspection of the injured limb, noting any deformity, swelling or bruising. Finally palpation of the limb and measurements should be carried out. If there is obvious deformity, palpation should be limited to an investigation of the relations of the fragments of bone to each other. It may not be necessary to carry this out until the patient has been anæsthetised. Palpation of the fragments of a fracture produces very great pain, and may considerably increase the shock.

If there is no obvious displacement, palpation should be carried out with a view to determining, first, whether there is any irregularity in the normal line of the bone; second, whether there is abnormal mobility at any spot; third, whether the bone is tender at any point; and fourth, whether by careful testing for abnormal mobility a feeling of crepitus can be obtained. Abnormal mobility is, of course, a most certain sign of fracture, but in many cases the presence of local tenderness is almost as important. This is particularly true of fractures near the ends of the long bones and of fractures of the smaller bones. Thus tenderness over the internal malleolus, the front of the ankle joint, and the fibula just above the external malleolus is so characteristic of Pott's fracture that where these three points are painful a fracture may be diagnosed with confidence even if there is no deformity, no abnormal mobility, and no crepitus. By crepitus we mean the sensation of grating yielded by movement of raw surfaces of bone against each other. It is a valuable sign in certain cases, but it should only be sought for when it is essential for the completion of the diagnosis. A very similar sensation may be obtained from movement of blood clot in a hæmatoma, so that crepitus may be a fallacious sign.

**Examination of the upper limb.**—In a doubtful case of injury of the upper limb a complete examination to exclude a fracture should take the following form.

The patient is seated upon a stool, the clothes being removed from both arms and chest. The arms hang at the side, the elbows flexed and the hands upon the knees.

Looking from the front, the line of the clavicles, shoulders and arms are first inspected; the subcutaneous surface of the clavicle is followed with the finger and the coracoid process felt. Then the shoulder is inspected from behind, the length of the shoulder from neck to acromion being compared with the opposite side, and the spine of the scapula, acromion process and acromio-clavicular joint are palpated.

Next, from behind, the head of the humerus on either side is grasped immediately below the acromion, any alteration in its position or size being noted. Then, while with the finger and thumb of one hand the head of the humerus is thus held, the elbow is grasped with the other hand and the shoulder movements tested, commencing with rotation and continuing with abduction, flexion and extension.

Coming now to the front, the elbows are extended and forearms supinated, the carrying angle at the elbow being noted. The elbows are then fully flexed, the tips of the fingers being placed upon the shoulder. In this position the bony points at the elbow, the internal and external epicondyles and the olecranon process are examined, and their respective positions determined. The range of movement at the elbow is noted. With one hand the elbow is grasped, the thumb being placed upon the head of the radius. The forearm is then pronated and supinated to determine the extent of this movement and

to feel that the head of the radius moves with the forearm. The forearm bones can then be followed with the finger to the wrist, the position of the styloid processes being noted.

The wrist-joint should be examined from the side in the position of full pronation, as well as from the front and back. All movements of the wrist joint must be examined and compared with those of the sound side, and a careful palpation made for any tender spots in the carpus, as well as for any abnormal prominence. A fracture of the scaphoid usually yields no signs except a local tenderness over the bone and a diminution in the range of full extension and of radial abduction. Finally the metacarpal bones and phalanges may be palpated, particularly for points of tenderness.

The best measurements in the upper limb are the length of the clavicle to the tip of the acromion, the distance from the acromion to the external epicondyle, the distance from the external epicondyle to the radial styloid process, and from the internal epicondyle to the ulnar styloid process.

**Examination of the lower limb.**—The patient is placed recumbent upon a couch with both lower limbs uncovered and the sides of the pelvis, including the anterior superior spines of the ilia, exposed. The concavity of the lumbar spine should first be noted, as a flexed hip is often obscured by a compensatory lordosis. In order to abolish a possible lordosis, the hip on the sound side should be flexed fully on the abdomen until the lumbar spine is quite flat. Any fixed flexion of the hip on the other side will then become evident.

Next the levels of the anterior superior spines should be noted. If possible they should be adjusted to the same level. If one hip is adducted, the anterior superior spine will be raised upon that side; if it is abducted, the spine will be lowered. When such a deformity is fixed it is not possible to adjust the anterior superior spine to the same level whilst the limbs are kept parallel. Any tilting of the pelvis in the antero-posterior or lateral planes being thus noted or corrected, the limbs should be placed parallel with each other, the patellæ pointing forwards and the feet vertical. A general comparison of the shape of the two limbs, the level of corresponding points, and of any apparent shortening or deformity can thus be made.

Before going further it is as well to measure the limbs. The ordinary measurement taken is from the anterior superior spine of the ilium to the tip of the internal malleolus. This gives a comparison for the whole limb. A second measurement from the anterior superior spine to the adductor tubercle of the femur gives a comparison of the length of the thighs. It is sometimes useful to measure from the tip of the great trochanter to the external malleolus, in order to determine whether the shortening is due to displacement in the region of the neck of the femur or of the hip joint. For comparison of the leg below the knee a measurement may be taken from the lower border of the patella to the internal malleolus.

Having completed the measurements, the region of the hip should be palpated. The first point to note is the position of the great trochanter, a comparison being made with the opposite side. The tip of the great trochanter may be raised, or may be further forward or further back, compared with that on the sound side. Elevation of the great trochanter is best determined by measuring Bryant's triangle. Marks should be made on either side on the anterior superior spine, and on the tip of the great trochanter. From the anterior superior spine a line should be drawn backwards at right angles to the couch on which the patient is lying, and the distance of the tip of the great trochanter from this line in the axis of the limb is measured and compared on

the two sides. This measurement varies a great deal in different patients, so that it is chiefly of value on comparison with the sound side, but if the great trochanter approaches within an inch of this line, or reaches above it, some abnormality of the neck of the femur or of the hip joint is certain.

A second method of estimating the height of the great trochanter is by Nélaton's line. The patient must turn on to his side, slightly flexing the hip. A tape is then drawn over the buttock from the anterior superior spine of the ilium to the tuberosity of the ischium. The tip of the great trochanter normally lies on, or very close to, this line. Again the measurement is chiefly of value when compared with that on the opposite side.

The movements of the hip may now be tested, starting with internal and external rotation. The arc through which the great trochanter moves on rotation may be important. With a sound femoral neck, the centre of the arc of rotation is in the head of the femur. If there is a fracture of the neck, the centre of the arc of rotation may be at the site of the fracture, so that the trochanter moves through an arc with a smaller radius. In the case of a fracture of the neck of the femur, crepitus may also be felt upon rotation.

Next, abduction, adduction, flexion and circumduction are tested and compared with the opposite side. The line of the shaft of the femur can be felt so far as the muscles permit, and the condyles and patella are easily palpated for irregularity or for tender points. The femur should be grasped at its upper and lower extremities and any abnormal mobility carefully sought for. Knee movements—first passive and then active—are tested, and the tibia and fibula then followed with the finger down to the malleoli. Any tender spots upon these bones are important, for fracture of the fibula or of one or other malleolus frequently yields no clinical sign other than local tenderness on pressure.

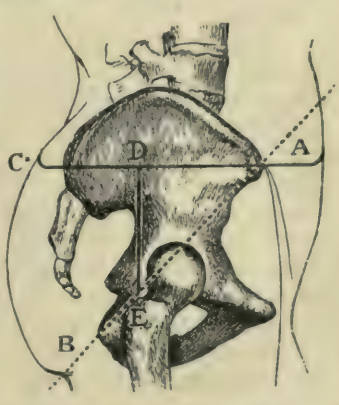



FIG. 203.—A—B, Nélaton's line. A—C, Bryant's line. A—D—E, Bryant's Triangle.

The ankle and heel should be inspected from front, back and side. An increased length of the heel points to displacement backwards of the foot, such as occurs in many Pott's fractures. An increased width below the malleoli may be due to fracture of the astragalus, or of the os calcis, or to a sub-astragaloid dislocation.

The ankle movements must be compared with those on the other side as well as movements of inversion and eversion at the mid-tarsal joints. All the tarsal bones and metatarsals must be palpated to determine the presence of deformity, displacement or of tender points.

A fracture of the scaphoid can be diagnosed only by the local tenderness, and fractures of the metatarsals, which may occur without known trauma, also give no evidence of their presence except upon pressure.

**Radiography of fractures.**—Whenever possible an X-ray photograph of a fracture or suspected fracture should be taken before any attempt at reduction is made. If, however, this would necessitate a considerable delay involving additional pain to the patient, increased shock and possibly greater difficulty in reduction, the X-ray should be dispensed with for the moment, being, however, taken after the fracture has been reduced. It is advisable always to take X-rays in two planes at right angles to each other, if this is possible.

A stereoscopic X-ray may be sufficient, but in certain cases the stereoscopic X-ray may fail to reveal a fissured fracture, which is obvious in a second view in another plane.

There are many fractures which can only be diagnosed for certain by an X-ray photograph. Usually they can be guessed at upon clinical examination, but before subjecting the patient to treatment for a fracture—for example, of one of the carpal or tarsal bones—a certain diagnosis should be made by means of an X-ray photograph.

**Constitutional symptoms.**—The most important constitutional symptom of fracture is shock. The incidence of shock depends upon the severity of the initial injury and the magnitude of the bone broken. Thus shock is greatest in fracture of large bones such as the femur, and in comminuted fractures. Other factors, however, are of importance. If the fracture has been associated with much hæmorrhage, shock will be increased. Pain, however, is the most important consideration. There can be no doubt that severe shock is often largely due to a persistence of afferent painful impulses, so that early reduction of the fracture and fixation upon a splint by lessening the pain greatly diminishes the shock. Gun-shot fractures of the femur in the recent war were accompanied by a very large mortality from shock. When the routine fixation of these fractures upon a Thomas's splint at advanced dressing posts was initiated the mortality at once fell very considerably. For this reason it is important that all severe fractures should be fixed on some retentive apparatus at the earliest possible moment, and before the patient is transported to a considerable distance.

During the early stages after a fracture the temperature falls during the stage of shock. A subsequent rise may be considerable. This rise is often ascribed to reaction. It is probable that in many cases it is due to absorption from extravasated blood. A temperature of 102° or 103° may occur after a fracture and give rise to a fear of suppuration taking place ; instead of this, the fracture—if simple—will almost always follow an aseptic course.

**Fat embolism.**—It is alleged that after a fracture fat globules from the medullary tissue enter the circulation and may give rise to embolism, and that when such embolism affects the pulmonary or cerebral arteries the condition may be fatal. The symptoms described are cyanosis, shortness of breath and signs of pulmonary œdema and pneumonia when the pulmonary arteries are affected, delirium and coma when the cerebral arteries are involved. The evidence that such symptoms are due to fat embolism appears to be totally insufficient, and the whole subject requires reinvestigation in the light of modern pathology. In two cases of death after osteotomy seen by the author, and thought to be due to fat embolism, post-mortem investigation showed that the death was due to uræmia, the kidneys being small and fibrotic. The passage of fat globules in the urine after a fracture has also been described. This also requires confirmation.

**Union of fractures.**—Three factors in the pathological anatomy of a fracture affect the mode of union to an important extent. The first is the extent to which the periosteum is stripped from the bone. The second is the amount of displacement of fragments persisting after the fracture has been reduced. The third is the presence of comminution—that is, of separate fragments detached from the two main ones. The fate of such detached fragments is still not quite certain. In some cases, although separate from the rest of the bone, they retain an attachment to the periosteum or to muscles, and thus have a possible blood supply. In others they are entirely detached and are, for the moment, foreign bodies. Such completely separate fragments resemble

grafts of bone interposed surgically in the tissues. By some it is believed that such a fragment must disappear and be replaced by new bone; by others it is thought that the fragments of bone may survive, their cells living until a new blood supply has been provided from the surrounding tissues.

When a fracture is simple (or if compound, when it is aseptic) there can be no doubt that these fragments do survive in the sense that they do not undergo necrosis nor act as foreign bodies. They become enclosed in the callus and assist in the ultimate union. Whether they retain their original structure or are replaced by new bone is of academic rather than of practical importance.

Immediately after a fracture has occurred the space between the ends of the bone and beneath the stripped periosteum becomes filled with blood, which soon clots. Organisation of this clot commences within twenty-four hours, the clot being vascularised and an ingrowth of cells occurring from the periosteum, from the medulla, and from the Haversian canals in the broken surfaces of the bone. The cells which thus penetrate the clot are doubtless of more than one variety. Some are fibroblasts, some osteoblasts, having a more definite bone-forming function. The new tissue thus formed is designated *callus*.

Three forms of callus are generally recognised according to the position in which they lie: that which is formed outside the bone under the periosteum is termed periosteal callus; that which unites the medullary cavities in the upper and lower fragments is termed endosteal callus; and that which lies between the actual ends of the bone is the intermediate callus. There is no essential difference in the callus formed in these three situations. In fact a differentiation of the three varieties is really only possible when practically perfect end-to-end apposition of the bone fragments has been secured.

The callus first formed is largely fibrous. In many, if not in all cases, patches of cartilage appear in this fibrous tissue. It is said that when perfect apposition is obtained the cartilage is absent, but that it occurs when any displacement persists. The next stage is the commencing ossification of the callus due to the action of osteoblasts which have grown into it from the deep layer of the periosteum or from the endosteum of the medullary canal and Haversian canals. The first bone to be formed lies under the periosteum, so that a fracture first becomes securely united by a sheath of new bone in this situation. At the same time ossification is taking place in the callus which blocks the ends of the medulla, so that at this stage the upper and lower parts of the medullary canal are shut off from each other by endosteal blocks of bone. Periosteal callus, containing sufficient bone to be demonstrable in an X-ray photograph, may be present in from twelve to eighteen days after fracture. This, however, is a minimum time. Bony callus may not be seen in an X-ray photograph until several weeks have passed.

The time required for actual consolidation, so that the fragments can no longer be moved upon each other, varies according to the size of the bone fractured, the severity of the fracture, the accuracy of the reduction, and the age of the patient. In small bones, particularly in the upper limb, consolidation may be good in four to six weeks. In a large bone, such as the femur, ten or twelve weeks or more will be required, according to the severity of the fracture. It must be realised, however, that the union that has thus taken place is by an intermediate mass, partly fibrous, partly bony, bulkier than the original bone, but far less strong. The callus at this stage, although possessing considerable resistance to a breaking strain, will often bend or mould if subjected to a continuous pressure.

The next stage in the healing of a fracture consists in a replacement of this

callus by true bone, possessing an architecture adapted to the stress to which it is subjected. If the fracture has been in the shaft of a long bone, and perfect apposition of the fragments has been secured, this eventual reconstruction is carried out by the absorption of the endosteal callus and its replacement by marrow, by the formation of compact bone between the ends of the compact bone above and below, and by the absorption of the periosteal callus. These changes take place as the result of the activities of the osteoclasts and osteoblasts which exist in the medullary and Haversian spaces of the bone, absorption of tissue, whether bony or fibrous, taking place wherever this tissue is no longer required to bear the strain, and deposit of new bone occurring in accordance with the pressure to which the union is subjected. If, however, apposition is not perfect, the process is a very different one. If, for example, a lateral displacement persists, new periosteal bone is formed externally and develops into a new cortex. The parts of the old cortex which lie in contact with each other are slowly rarefied and absorbed. Eventually this cortex may disappear altogether and the medullary cavity may be reconstituted through the line of union.

Fig. 204. — Fracture of the femur with overlapping fragments to show rounding off of angles, and restoration of medullary canal by absorption of intervening bone. (St. Bartholomew's Hospital Museum.)

The reconstruction of the shape and architecture of the bone, so that it best fulfils its function of resisting pressure, is usually described as Wolff's law. The fact that bones are in a constant state of flux, always adapting themselves to their function, was, however, recognised by Hunter and by Flourens long before Wolff's time. Wolff's law is thus usually stated: "Every change in the form and function of a bone, or of its function alone, is followed by certain definite changes in its internal architecture and equally definite secondary alterations in its external conformation in accordance with mathematical law."

**Treatment of fractures.**—The immediate or first-aid treatment for a fracture has as its objects the prevention of further injury, the diminution of shock and pain, and the prevention of excessive swelling.

Further injury may take place if the fragments of the bone are allowed to penetrate the tissues. They may thus perforate the skin and render the fracture compound, or they may damage important structures such as vessels and nerves. Even if they do no such serious harm, the movement of the fragments causes additional injury to the muscles and thus affects the ultimate recovery of use in the limb.

As has already been seen, shock may be reduced by preventing movement of the fragments and by diminishing pain. The simplest method of preventing further injury by the movement of fragments and of diminishing pain is by the immediate application of a splint upon which traction upon the distal part of the limb can be maintained. For fractures of the femur, tibia and fibula, a Thomas's splint is undoubtedly the best first-aid appliance. It can be slipped on over the clothing, and traction can be exerted by a simple device suggested by Major Meurice Sinclair. A metal skewer is passed through the upper of the boot, just above the sole. Two cords on either side pull this down and are fastened to the lower end of the splint. In the upper limb a

Thomas's straight arm splint also forms the most convenient appliance. The ring of the splint presses against the axilla, and a simple clove hitch applied around the wrist pulls the hand down to the lower extremity of the splint. If the patient has to be transported far before the fracture can be finally fixed it is as well to take steps to prevent excessive swelling. The whole of the injured segment of the limb should be encased in a sheet of cotton wool and a firm bandage applied from below upwards, so that elastic compression is exerted upon the site of the fracture.

The most important stage in the treatment of a fracture is the reduction of the displacement and fixation in the corrected position. Reduction should be carried out as soon as possible, because when the fragments are in place pain is at once diminished and shock lessened. Moreover, soon after a fracture has occurred reduction may be easy, because the muscles around the bone are still flaccid and do not greatly impede movement of the fragments. After an hour or two a spasmodic contraction of the muscles sets in, preventing reduction of the fragments until the patient is anæsthetised. Within twenty-four hours of the occurrence of the fracture, hæmorrhage at the site will have ceased and organisation of the blood clot commenced. If reduction is left until this stage fresh hæmorrhage is caused, and the already organising blood-clot must be torn and disturbed by the manipulations. But anxiety to get the fractured bone into good position as quickly as possible should not lead to an attempt at reduction before all the required facilities are at hand. The patient should be anæsthetised and splints, or their equivalent, must be ready. If no anæsthetist is available, and no splint ready, only such manipulation as is necessary to relieve pain and fix the fracture temporarily should be carried out.

*Most fractures yield a good or bad result according as the displacement is properly reduced and the fragments placed in correct apposition or not.*

The use of particular splints, of massage, of movement of joints, or of fixation of joints, and of all other details of treatment is frequently given as the cause of success or of failure in the treatment of a particular fracture. It cannot be too clearly understood that in almost every case a good or a bad result from a simple fracture depends upon a perfect or an imperfect reduction of the fragments. Colles's fracture of the wrist is one of the commonest of injuries. When a Colles's fracture has been completely reduced, a good result is practically assured whatever the after treatment. When the deformity has not been completely reduced the result cannot be perfect, although the use of early movement may restore a considerable proportion of the functional utility of the hand.

Before commencing reduction an attempt should be made to estimate the exact displacement of the fragments and, if possible, the forces which have probably produced this displacement. The mobility of the fragments upon each other should be tested and the presence or absence of impaction recognised. An X-ray photograph will, of course, assist in this investigation.

Reduction must to a large extent depend upon the experience of the surgeon, his knowledge of the mode of production of individual fractures, of the difficulties that have to be overcome, and of the tendency of any fracture to relapse into a bad position as soon as it is left to itself.

Certain general rules for reducing fractures may be laid down. The application of these rules to the more common fractures will be described in greater detail under the individual fractures.

The objects of the manipulations are first to disengage the fragments so that they are freely mobile and so that there is no interposed tissue; second,

to overcome the muscular resistance; and third, to bring the fragments into proper alignment. If the displacement has been produced by the original force which fractured the bone, it is a safe rule to attempt to disimpact and free the fragments by moving the distal part of the limb in such a way as to increase the deformity. For example, in a Colles's fracture, the force acting upon the front of the dorsiflexed wrist has driven the lower fragment of the radius backwards, impacting into it the posterior border of the upper fragment. By still further forcibly extending the wrist the lower fragment can be disimpacted and rendered freely mobile, so that it can subsequently be pulled down into its proper position.

In a fracture of the lower end of the humerus, produced by a fall upon the hand, the lower fragment is often driven backwards, so that it lies behind the upper. It can be disengaged from this position by hyperextending the elbow, and then exerting traction. Full flexion of the elbow will then, in most cases, completely reduce the displacement.

In a Pott's fracture the foot is displaced backwards and outwards at the ankle-joint. If there is any difficulty in restoring the correct position, the foot should be forced still further backwards and outwards before attempting replacement. When free mobility at the site of fracture has been obtained, the heel can be lifted forwards and the whole foot forced inwards, usually without much difficulty.

In some fractures the pull of particular muscles prevents reduction. A position must then be secured which will cause relaxation of these muscles.

In a fracture of the lower end of the femur the lower fragment is tilted backwards into a flexed position by the gastrocnemius. Full flexion of the knee and plantar flexion of the foot are required to relieve this. Sometimes there will be a difficulty in maintaining a good position because there is a persistent tendency for this flexion of the lower fragment to recur. In this case it may be necessary to fix the fracture with the knee flexed, so that the gastrocnemius is relaxed.

Before finally fixing a fracture it is as well to over-correct the displacement. The reason for this is that it is advisable to get the fragments to come into good alignment without the exertion of any considerable force. This is more easily secured if those structures which prevent replacement have been thoroughly overstretched. Another reason is that it will often be found that a reduction which is apparently complete is shown by an X-ray photograph not to be so. Thus a Pott's fracture, in which the foot is apparently straight, will very often turn out to have a considerable valgus deformity. It is safer to invert the foot from the first.

A second X-ray examination should, if possible, follow reduction of the fracture. In some difficult cases it is worth while anæsthetising the patient in the dark room and manipulating with a fluorescent screen over the fracture. It is often possible thus to determine the reason for a difficulty in reducing the fracture and to overcome this difficulty.

A complete and perfect replacing of the fragments from a fracture is not always possible, nor is it always necessary. The test for reduction is to get good alignment of the bone in both coronal and sagittal planes, to restore the length of the limb, and to secure that the joint surfaces lie in the correct plane. If the fracture has passed through a joint surface it is important to make sure that the fragments entering into the formation of the articular surface are in complete apposition with each other. Whenever attempts to reduce a fracture have failed to restore proper alignment, length and position of articular surfaces, an operation for the replacement of fragments in good position should

be undertaken, unless the patient's condition contra-indicates it, or unless it is one of a few special fractures in which good union is not to be hoped for. The test for the necessity for an operation should always be the consideration as to whether the displacement remaining will seriously interfere with the functional use of the limb or whether it will be of purely æsthetic importance.

**Fixation.**—The object of the use of splints or other methods of fixation is to maintain the fragments of a fracture in proper position. All fractures are not equally liable to a recurrence of the displacement. In most fractures of the ends of long bones, displacement once reduced, the position can be maintained by simple means with little pressure and without traction.

For example, a Pott's fracture can be held by simple lateral splints. A Colles's fracture, if properly reduced, may, in many cases, be left without a splint. A fracture of the lower end of the humerus remains in perfect position if the elbow is kept fully flexed and the forearm supinated. In such cases simple fixation splints, bandages, or plaster of Paris are all that are required.

In the second group of fractures the position of the limb is the important point, the weight of the limb causing a recurrent displacement of the fracture. For example, in fracture of the clavicle, the inner end of the bone remains in its ordinary position, or is tilted a little bit upwards and backwards. The outer extremity, when the weight of the arm hangs upon it, falls so as to make an angle with the inner portion. If the arm is supported in such a way that the point of the shoulder is lifted and drawn back, the fragments of the clavicle come into practically perfect position.

FIG. 205.—Fixation of the shoulder and arm in a plaster case.

In fracture of the surgical neck of the humerus, the upper fragment is usually abducted by the action of the supra- and infra-spinati ; if the arm is allowed to hang, the lower fragment of the humerus forms an angle with the upper. If, however, the arm is held in a suitable degree of abduction, proper alignment can be maintained.

In the third group of fractures the pull of longitudinally disposed muscle keeps up a continuous tendency to produce over-riding of the fragments. This is particularly the case in fractures of the femur. In fractures of this sort a continuous extension upon the lower fragment is necessary during the early stages of treatment.

Fixation of fractures depends, then, upon the adoption of three principles : first, the maintenance of a particular attitude of the limb ; second, the use of extension in appropriate cases ; and third, the use of retentive splints.

Fixation is necessarily dependent upon reduction. When a fracture has

been satisfactorily reduced, retention will in most cases be comparatively easy. When the reduction has only been partial, retention even of this partial reduction will be much more difficult.

**Methods of fixation in the upper limb.**—Except in a few special cases the fixation of a fracture of the upper limb necessitates immobilisation of the joints above and below the fracture. Whenever it is possible, such immobilisation can be most efficiently carried out by fixation in plaster of Paris, as by this method the limb can be fixed in any required position at the will of the surgeon. Practically the only conditions that contraindicate the use of plaster are the presence of infected wounds, which are too considerable to permit of dressings being carried out through a window in the plaster, and the necessity for a continuous extension upon the lower fragment in order to maintain position. It is very seldom that a continuous extension is required in a fracture in the upper limb.

Fig. 206.—Shoulder abduction splint.

When a recent fracture is being fixed in plaster it is necessary to guard against the occurrence of any considerable swelling inside the plaster case. It is not advisable, however, to leave the plaster loose, and so to permit the swelling to occur. The best method is to encase the limb in a complete layer of cotton wool carefully and evenly arranged, and then to bandage from below upwards with a flannel or domette bandage, exerting a firm uniform pressure. If the fracture has occurred some days before, or if it is being refixed for the second or third time, it is unnecessary thus to pad the limb; it is better to use as little dressing or bandage as possible underneath the plaster. A single layer of flannel bandage or a layer of stockinette is quite sufficient. Provided that the plaster of Paris bandages are applied smoothly and without tension, and are moulded upon the limb as they set, there is no risk of producing sores unless a localised pressure is produced upon particular points. Whenever it is expected that such localised pressure will occur, a layer of felt should be inserted beneath the plaster.

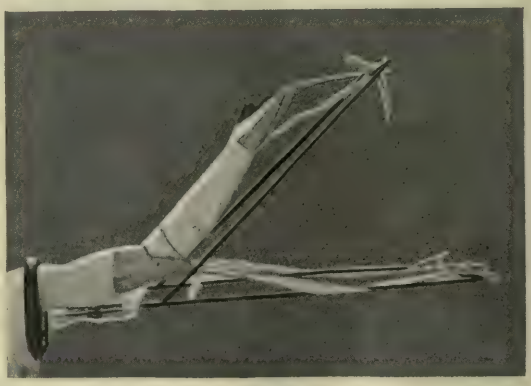


Fig. 207.—Thomas's arm splint with elbow flexing iron.

In a fracture of the shaft or upper end of the humerus fixation in a plaster case of the type shown in Fig. 205 is the most efficient method. In fixing the

right arm pads of felt are applied over the right hip and beneath the left axilla; the arm and chest are then enclosed in a flannel bandage. The plaster case encloses the arm from the wrist upwards, the whole of the chest, the right side of the abdomen, and the shoulder-joint being included. A strip of metal—18 gauge and 1 inch wide—bent to the required angles is included up the right side of the chest and beneath the arm as far as the elbow, and a second strip may, if necessary, be used to reinforce the under surface of the forearm plaster. The plaster case is strengthened and moulded over the right hip and beneath the left axilla. It is cut away from the whole of the left side of the abdomen. In such a plaster the weight rests upon the right hip, the section around the left side of the chest preventing the whole case from tilting.

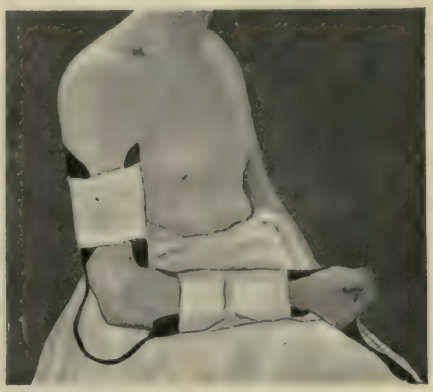


FIG. 208.—Posterior angular splint with small metal splints on front of arm and forearm.

In fractures of the lower end of the humerus, splints or plaster are unnecessary, fixation by strapping being sufficient.

When the forearm has to be fixed in plaster it should, as a rule, be held at a right-angle and in a supinated position, unless there is some special reason for deviating from this rule. No padding is required other than a flannel bandage, and the plaster case should include the wrist (which must be extended), the palm of the hand, the whole of the forearm, and the lower half of the arm.

Comparatively few splints are of use for fixation of the upper limb. The shoulder abduction splint serves the same purpose as the shoulder plaster already described. It has a metal plate which rests upon the hip, and gutters, in which the arm and forearm rest—the joint at the elbow being hinged and mobile. The degree of abduction can be varied by bending the upright which connects the body section with the gutter on which the arm rests.

FIG. 209.—Long cock-up splint.

The straight Thomas's arm splint is the most useful appliance for the occasional cases in which a continuous extension is required upon a fracture of the shaft of the humerus. The splint consists of a ring which encircles the shoulder and presses against the chest wall beneath the axilla, and of two lateral bars united at the distal end. These bars may be welded to the ring, or may be movable upon it by hinged joints (swivel splint). There is a considerable risk, when the straight Thomas's splint is used, of producing severe stiffness of the elbow-joint. This is best overcome by

attaching an elbow-flexing iron—that is, a second pair of lateral bars hinged opposite the elbow, so that this joint may, after a time, be slowly flexed. The extension upon the arm should be carried out by affixing strapping laterally just above the elbow, secured by a circular strip of strapping and a flannel bandage. When the flexing iron is used, a second strapping extension should be attached antero-posteriorly to the forearm and carried to the end of the forearm iron.

For fixation of the bones of the forearm the best splint is a posterior angular, consisting of two metal gutters which rest against the posterior surfaces of the arm and forearm, and which are joined by a right-angled metal bar. The forearm rests in this splint in the fully supinated position and is secured by a small anterior gutter splint.

Sometimes in a compound fracture the necessity for carrying out dressings renders the use of a skeleton splint advisable. Such a splint consists of a posterior gutter for the arm and of two side bars bent at a right angle at the elbow and extending beyond the hand as a hoop. When the arm has been bandaged in place upon this splint, the hand may be extended to the hoop

FIG. 210.—Thomas's splint showing method of fixing and slinging foot (the strapping extension should be covered with a bandage).

by enclosing it in a cotton glove, which is glued to the fingers with Sinclair's glue, tapes attached to the extremities of the fingers of the glove being used to secure the extension.

For fixation of the distal part of the forearm and wrist, simple gutter splints or a short cock-up splint may be used, according as it is desired to hold the wrist in a straight line or extended. If both the wrist and fingers are to be extended, a long cock-up splint may be used.

**Fixation in the lower limb.**—The use of plaster of Paris for the lower limb requires no special mention, except in cases in which it is used for high fractures of the femur, in which abduction of the hip is desired. When such a fracture is fixed in plaster, as, for example, it should often be in children, it is desirable to start the plaster case at the toes, to include the hip and pelvis and the trunk up to the axilla, particularly strengthening the sides of the plaster opposite the chest. The whole of the anterior part of the plaster over the chest and abdomen may then be cut away with the exception of a narrow strip across the pelvis. The presence of wings of plaster against the sides of the chest will effectually prevent abduction of the hip.

In small children and in patients in whom it is considered undesirable to cover too much of the chest abduction of the hip will be best secured by enclosing the upper part of the opposite thigh in the plaster.

Fractures of the femur in many cases necessitate the use of continuous

extension, and this contra-indicates fixation in plaster of Paris. In fractures below the knee, however, the use of plaster of Paris is nearly always the best method of fixation.

The straight Thomas's bed splint can be used for a large proportion of fractures of the thigh and leg. It is unsuitable for Pott's fracture and other fractures of the ankle and foot.

Extension upon the limb inside the Thomas's splint can be carried out by two principal methods :—

1. The use of an external extension of strapping or glue.
2. The use of calipers or other appliances which penetrate the skin and grip some part of the bone.

The former method is always to be preferred when it is practicable and efficient.

The best material for making an extension is Leslie's strapping. Two strips of this are cut, each 2½ inches wide and long enough to reach from the sole of the foot to the middle of the thigh, or to above the line of the fracture. At the lower end the strapping is folded back upon itself and stitched, so that the smooth surface will rest against the malleoli of the tibia and fibula, and not adhere to them. Through the loop formed by folding back the strapping a piece of strong inch webbing is passed and tied. Each strip of strapping is then split into three strands, the central wider and two lateral narrower. The central strands are stuck up each side of the limb in a straight line, reaching to a point immediately beyond the level of the fracture. The lateral strands are wound obliquely around the limb forwards and backwards, so as to cross each other at intervals. The whole is then covered with flannel bandage from below upwards. In order to prevent soreness of the skin, which may necessitate the removal of the extension, certain precautions must be taken. The most important of these are (1) that the strapping should everywhere be laid on smoothly and without folds or creases ; (2) that it must not adhere to the limb at a lower point than 1 inch above the malleoli ; and (3) that neither strapping nor the bandage must be tight over the tendo Achillis or the front of the ankle. Sinclair's glue * extension is simpler to fix, but has the disadvantage that some stocks of glue tend to produce blistering of the skin. Two long strips of gauze are applied down each side of the limb and fixed by painting with the glue, which has been liquefied by standing in hot water ; a plain cotton bandage is then applied. The ends of the gauze are themselves used for tying to the extremity of the Thomas's splint.

In fixing a fracture of the femur in a Thomas's splint the splint is first pushed right home against the tuberosity of the ischium, the extensions are wound once round the side bars, drawn on, and tied to the end of the splint. A posterior gutter splint is inserted behind the fracture with any padding that may be necessary to make sure of lifting the fracture forwards sufficiently, and cross slings of flannel are inserted and fixed to the outer bar with clips.

In fractures of the lower half of the femur it is generally desirable to bend the Thomas's splint opposite the knee joint, so that the knee remains slightly flexed throughout the treatment.

The pull exerted, through an extension, upon the lower fragment of a fractured femur may amount to as much as twenty or thirty pounds, or even more. This pull necessitates an equal counter-pressure or traction in the opposite direction. When a Thomas's splint is used the counter-pressure

* *Formula for Sinclair's glue :—Best skin glue*, 50 *parts ; water*, 50 *parts ; glycerin*, 4 *parts ; thymol*, 1 *part.*

comes against the tuberosity of the ischium, where the ring of the splint presses. This pressure may be very uncomfortable and may even produce a sore. It can be easily relieved by suspending the splint and applying a weight extension to its distal end. The simplest method is to suspend the splint by four cords, two attached at the upper end, two near the foot; these pass over pulleys on a Balkan frame, and have sandbags attached as counterpoises. A fifth cord is fixed to the extremity of the splint, passes over a pulley at the end of the frame, and has a sandbag attached, the weight of which is varied according to the amount of extension required. In order to prevent the patient being pulled down the bed, the foot end of the latter should be raised upon blocks. The higher the blocks the more efficient the extension. When a powerful extension is required, 10 or 12-inch blocks should be used. A daily inspection of the splint is necessary to make sure that the ring is still

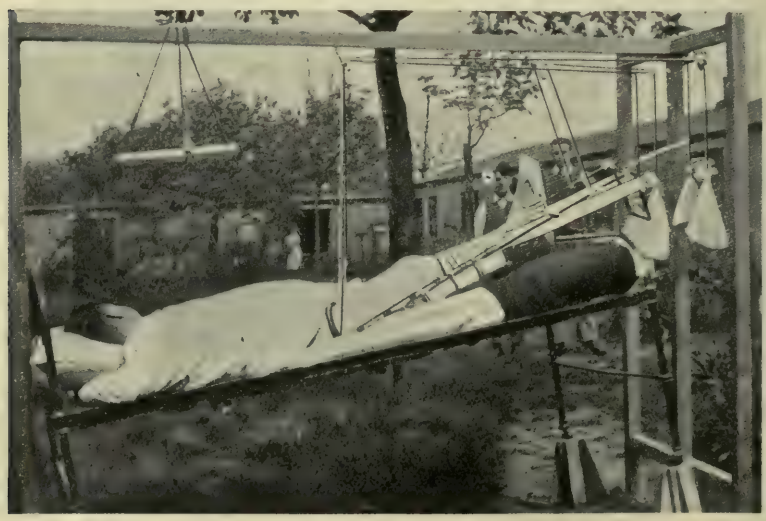


FIG. 211.—Sinclair's method of applying a Thomas's splint with glue and gauze extension and Sinclair footpiece, suspended to a three-post frame. (From a photograph supplied by Mr. W. E. Wilson.)

close up against the tuberosity of the ischium. If it comes away from this point after the fracture has once been fully reduced the extension must be slipping and will require readjustment.

The foot should be supported in the Thomas's splint by using a hoop to which it is hung by glue or strapping. As the foot and toes tend to become stiff during the treatment of a fractured femur, it is desirable to have these massaged daily whilst the patient is fixed in a Thomas's splint.

In fractures high up in the femur, when abduction of the hip is required, the most comfortable method is to apply a Thomas's splint with extension on each of the lower limbs, to suspend these in a four-post frame, applying weight extension to the end of the Thomas's splints in an abducted position, and adjusting the weight on each limb and the degree of abduction, until the anterior superior spines of the pelvis are level.

A caliper affixed to the condyles of the femur may be used as a method of applying extension to the lower fragment instead of the strapping or glue. In inserting the caliper a small incision is made over each condyle with careful

aseptic precautions, but the grip of the caliper should consist of small points which only just enter the supracondylar ridges of the femur where they are widening out. As a rule, when a caliper is used, the Thomas will have a knee-flexing iron attached, similar to the elbow-flexing iron of the arm splint. The cord attached to the caliper is fastened to the main iron of the Thomas, the leg resting separately in slings on the knee-flexing iron. The chief advantage claimed for the use of a caliper extension and a knee-flexing iron is that mobility of the knee can be preserved throughout the treatment of the fracture.

Fractures of the tibia can also be conveniently treated on a Thomas's splint. Sometimes there is room below the fracture to apply a strapping extension by the method already described. Sometimes an extension by Sinclair's footpiece will be required. The latter consists of a wooden plate with a cross-piece of metal, to which the extension cords are tied. A series of flannel bands is first glued to the sole and dorsum of the foot. Each of these carries two small rings to which tapes are attached and tied over the serrated edge of the footpiece. The extension that can be obtained from this footpiece is not very considerable, but is sufficient for most fractures of the tibia and can be used for fractures of the femur as a temporary method if the skin is rendered sore higher up the leg.

In using a Thomas's splint for a fracture of the tibia it is necessary to watch the position of the knee. Unless the knee is maintained in a slightly flexed position, and with the patella looking forwards, there is a tendency for the thigh, knee, and upper fragment of the tibia to rotate out; then, if the foot has been kept vertical, it will be found that, when union has occurred, there is an axial deformity of the limb, and the foot points inwards. The best method of guarding against this is to bend the Thomas's splint opposite the knee-joint and to include the knee in a plaster of Paris case, which is secured to the side bars of the splint. The position of the patella is thus fixed, and the foot can be rotated so as to lie in proper relationship with it.

The only other splints required in the lower limb are simple metal gutter splints of various sizes, the posterior knee splint with footpiece, and the club-foot shoe.

**Massage.**—The term massage is generally used to include both massage and the use of active and passive movements.

By massage proper is meant the effects of stroking, kneading, percussing, or vibrating some part of the body with the hand. The effects of massage are various. In the first place analgesia of a painful part can be produced by stroking. Then friction, kneading, percussion or vibration all produce important effects upon the circulation, rendering the part hyperæmic, dilating the arterioles, and increasing the flow of blood through the part treated. Mechanical effects are also produced, friction and kneading helping the passage of lymph from the part and so reducing swelling, whilst the deeper movements by moving the muscles and deeper tissues upon each other prevent the formation of adhesions and soften and loosen those already present.

Massage in fractures may be used to assist the absorption of effusion, to keep the soft parts mobile, and thus prevent subsequent stiffness. But massage may be used also to produce two specific effects. Lucas Championnière introduced the use of massage at very early stages in the treatment of fractures for the production of analgesia. His method has been adopted with success in this country by Mennell. By repeated stroking over the area of a recent fracture an analgesia may be produced, accompanied by a relaxation of spasm in the muscles. As a result it is sometimes possible to reduce a

fracture completely by simple slow manipulation, without the administration of any anæsthetic.

Deep massage has undoubtedly the effect of promoting the formation of callus, and of increasing the rapidity of ossification. An experiment upon this has been carried out by treating a fracture of the tibia produced by osteoclasis for rickety bowing of the tibia by massage. In a child, in whom both tibiæ were broken and one side was massaged and the other left alone, bony periosteal callus was demonstrated in an X-ray photograph on the twelfth day on the side massaged—on the seventeenth day on the other side.

Deep massage may, therefore, be used to promote the formation of callus, more particularly in cases of delayed union.

When the treatment of fractures by early massage is spoken of, treatment by both massage and movement is usually meant. Opinions as to the value and safety of early movement in the treatment of fractures differ. By some it is thought that early movement is the one way of preventing subsequent stiffness ; by others that such early movement, by rendering fixation difficult, allowing movement of the fragments upon each other and thus increasing the callus, eventually gives rise to increase of stiffness and disability. The essential principles of the use of movement in fractures should be :—

1. That movements must be normal joint movements, must not include movements of the fragments upon each other, and that in fact no movement which is likely to disturb the position of the fragments can be allowed.

2. That no forced movements should be carried out, at least not until consolidation is complete ; and

3. That use of the muscles should be allowed and encouraged as soon as is consistent with the safety of the position of fixation.

The actual programme to be adopted in commencing massage and movement upon the fracture must depend upon the individual fracture. In fractures such as a Colles, where fixation is simple, early massage and movements should be carried out. In fractures such as those of the femur, where the maintenance of position is difficult, early massage and movements can much less often be adopted. The use of early movement is most important in fractures in the neighbourhood of the joints, not simply because there is a tendency to stiffening of the joints, but because tendons in the neighbourhood of the fracture are apt to get stiff and adherent. In fact, the use of small movements which involve the action of muscles and the movements of tendons in their sheaths is of greater value than is the use of the larger joint movements.

In general, then, we may say that the movements to be encouraged are active ones carried out by the patient himself, for these will be muscular movements and will not risk displacement of the fragments, because the patient's own muscles can be trusted to stop short in a movement when acute pain is produced.

In fractures in which actual joint movements cannot be allowed muscular action can be carried on by using the faradic coil to stimulate the muscles around the fracture. For example, in a Colles's fracture all the forearm muscles may be stimulated in turn with a surging faradic current ; in fractures of the femur the quadriceps muscle may be similarly treated. The use of such stimulation keeps the muscle healthy and active, assists absorption and prevents adhesions around the muscle and tendon.

Passive movement in fractures is to be discouraged. It is far more likely to cause a displacement of the fragment than is active movement. Moreover, passive movement often means that young, organising fibrous tissue is stretched and torn. Such tearing will probably produce a fresh effusion with

a growth of new fibroblasts and production of more fibrous tissue, so that the constant stretching of adhesions tends rather to the production of still more fibrosis.

In certain fractures, particularly those in the neighbourhood of the elbow, traumatic myositis ossificans occurs in the muscles. This pathological process is undoubtedly rendered far worse by massage and by passive movements. The production of such an inflammatory reaction is one of the real dangers of the use of massage and of passive movements in fractures. The occurrence of this process does not necessarily mean that the massage and movements were inadvisable, but it does mean that they were wrongly applied.

Pain is a good indication of the value of massage and movements in any individual case of fracture. If the treatment produces pain which persists for more than half an hour afterwards it is probably doing harm, for such persistent pain is evidence that damage is being done or inflammation provoked which is likely to increase the subsequent stiffness.

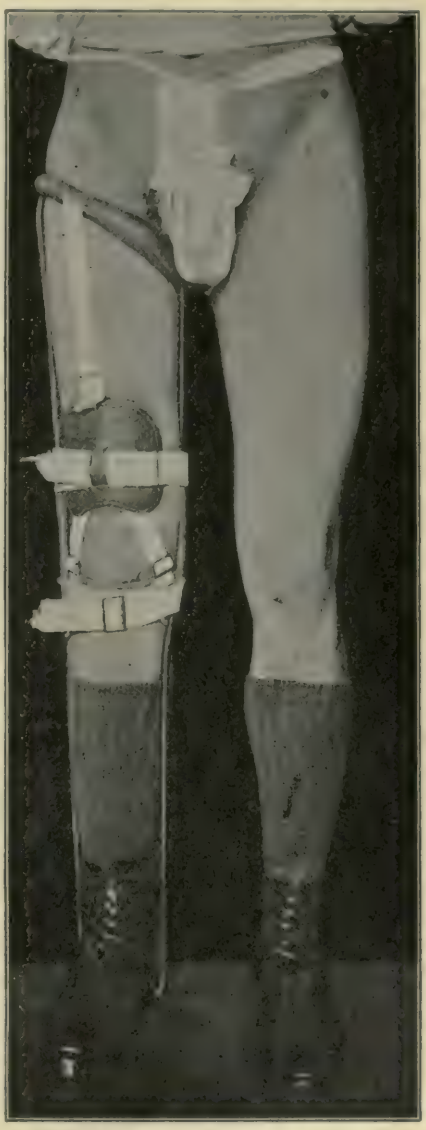


FIG. 212.—Thomas's caliper splint.

**After-treatment of fractures.**—As already explained, a fracture is first united by callus. Only after a considerable time is the proper architecture of the bone restored. Until this restoration has taken place a persistent strain in one direction upon the site of the fracture may easily produce bending. The fractured area must therefore be protected from such a strain until such time has elapsed as will allow of a proper internal reconstruction of bone. The time required for these changes to take place varies very greatly according to the bone involved and to the severity of the injury. An example of this has been seen in gunshot fractures of the femur. In a simple fracture of the femur, with good alignment, union may be expected to be good in from ten to twelve weeks. The bone is not fully strong at that period, and a walking splint, to be worn for another two months, is advisable. In gunshot fractures consolidation is often much slower, but in favourable cases union is clinically complete, perhaps, in twelve weeks. It has been found, however, that it is necessary for the patient to wear a walking splint for six to twelve months

afterwards, because if he walks upon the limb without it, either bending of the callus or refracture may take place. It is important to recognise this fact—that union is not really finished until the bone has reconstructed its architecture, because during this time the use of the limb must be careful, movements must not be forced, and in the lower limb a supporting appliance must be used.

The treatment of a fracture is not completed when good union has been secured The aim of treatment is the restoration of functional use—that is, the restoration of as full as possible a range of active movement in all the joints of the limb, the re-education of the upper limb for work, the restoration of power of weight-bearing, and of walking and running in the lower limb.

This final restoration of function is carried out by the use of physical treatment—massage, various forms of baths, including light baths and heat baths, passive movement, active movement and re-educational exercises. It must be understood that these are all means to an end—the end being the restoration of strong active movement.

In military and in industrial surgery it is not unusual to find that a fracture

Fig. 213.—Method of fixing the socket in the boot for a caliper splint or for a side iron. The figure on the right shows the socket complete, that on the left the position in which it is fixed into the boot. In the latter the tube has been cut across to show a section.

which has united satisfactorily has left considerable disability in the limb. Such a disability constitutes to the patient a claim for compensation. Where, however, the disability is not dependent upon the position in which the fracture is united or upon co-existing injuries, but upon the failure to restore use, it should be considered as a temporary condition, indicating a further period of active physical treatment.

**Ambulatory treatment of fractures.**—By the ambulatory treatment of fractures is meant the use of splinting appliances for the lower limb which allow the patient to walk upon the limb without the use of crutches at an early stage of treatment. Practically all such appliances depend upon the use of the principle of the Thomas's knee splint, the weight being transmitted from the pelvis direct to the ground through a ring upon which the tuberosity of the ischium rests. It is possible to fit a patient with a fractured femur with a Thomas's knee splint, to extend the leg to the bottom of the splint, and to fix the fractured area by small fixation splints. In such an appliance the patient may be able to walk. Hessing's appliance is an elaboration of the Thomas's splint. The patient is placed upon an extension table, and the limb pulled out until its length is full, and the fracture manipulated into position. A plaster of Paris cast of the entire limb is then made. Upon a model thus secured a steel and leather appliance, which extends from the

pelvis to the ground, with hip, knee and ankle joints, is manufactured. In such an appliance, provided that the knee is kept almost or entirely extended, the patient may be able to walk. If the knee is allowed to flex freely, the extension action of the splint fails and movement of the fragments will take place. Such an appliance is elaborate and costly. Whether it can be used at an early stage must depend upon the severity of the injury of the soft parts, the amount of swelling, and the patient's ability to bear pain. It is an excellent appliance for convalescent use instead of the Thomas's caliper splint. The latter, however, has great advantages of simplicity and cheapness, which are important in a splint which will only be required for a few months.

Delbet's method of ambulatory treatment is another elaboration of the principle of the Thomas's splint. A metal crutch is fixed round the top of the thigh against the tuberosity of the ischium. This is connected by three vertical rods to a plaster of Paris case, which encloses the lower extremity of the thigh and the whole leg and foot. The three rods can be extended and clamped in the extended position. By this means an extension upon the fragments of the femur is kept up with counter-pressure against the tuberosity of the ischium.

Ambulatory methods can be applied to fractures of the tibia by modifications of the use of the Thomas's splint, Hessing's appliance, or by Delbet's method.

**Delayed union and non-union.**—When a fracture has failed to unite firmly after an interval of time which is generally sufficient for the particular fracture, union may be said to be delayed. In certain cases of delayed union further time and treatment will result in ossification of the callus. In certain other cases union by bone never occurs, and the condition of non-union is present.

When union has failed completely the ends of the bone will be joined together by fibrous tissue ; if union is by strong fibrous tissue and the interval between the bone ends is small, the condition is one of close fibrous union. In certain bones bony union never occurs without operative treatment, fibrous union being the normal result of the fracture. This is the case, for example, in the patella, in which the upper fragment is held away from the lower by the pull of the quadriceps muscle, and in the small bones of the carpus—probably because complete fixation of the fragments is impossible.

In some cases of non-union a complete false joint is formed between the ends of the bone with a synovial membrane containing fluid and a fibrous capsule, the surfaces of the ends of the bone becoming rounded, sclerosed and covered with dense fibrous tissue. The false joint (*pseudarthrosis*) may be of the nature of a hinge or of a ball and socket joint.

The causes of non-union of a fracture are :—

1. Failure of proper apposition of the ends of the bone. This may be due to a loss of substance of the bone, more particularly in fractures of one of a pair of parallel bones, such as the radius and ulna. If an inch of the radius has been destroyed the ends are kept apart by the existence of an unfractured ulna.

Another cause of failure of apposition is the weight of the distal portion of the limb, distracting the lower fragment from the upper. This is probably one reason for the frequent occurrence of non-union in the humerus.

In all cases of failure of apposition the chief factor is the absence of continuity in the periosteum. If there is a complete periosteal sheath, union will probably occur across a gap ; if there is no complete periosteal sheath, new bone may be thrown out from the fractured ends for a short distance, but only a very small gap is likely to be filled in this way.

2. Failure of fixation. Only in very gross cases will failure of fixation tend to produce failure of union.

3. The interposition of muscle or fibrous tissue between the ends of the bone.

4. Sepsis producing necrosis of the fractured ends with sclerosis of the surrounding bone. This tends to prevent the formation of endosteal and intermediate callus, but not of periosteal callus. Therefore sepsis only produces failure of union when the periosteum has been very extensively damaged.

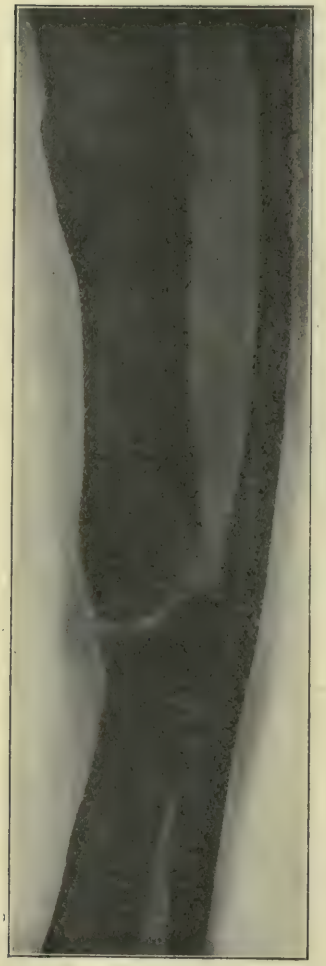


FIG. 214.—Ununited fracture of the tibia, with intact fibula. The latter bone has kept the fragments of the tibia apart and caused them to bow laterally.

FIG. 215.—The result of an oblique osteotomy of the fibula in this case. The fragments of the tibia have come into contact, and the bowing is to a large extent corrected.

5. Defective blood supply is commonly given as a cause of failure of union in particular situations—for example, in fracture of the neck of the femur, where the head of the bone has a poor blood supply; in fracture of the shaft

of the humerus, below the point of entry of the nutrient artery, and in fracture of the tibia in its lower third. In both the latter cases failure of union occasionally occurs not from any mechanical cause, but apparently because of the failure of the bone to throw out sufficient callus.

6. In some cases of pathological fracture due to paralysis, or other nervous disease, failure of union occurs.

7. New growths of bone.

8. Osteomalacia and rachitic osteomalacia.

9. Certain constitutional diseases, particularly syphilis, nephritis, scurvy, anæmia, as well as old age, are often given as causes of failure of union. In the absence of any actual manifestation of disease at the site of the fracture, there is no evidence that these constitutional causes are of any importance.

Delayed union should be treated, first, by the elimination of any septic infection, the removal of sequestra, and final cure of any chronic sinus.

If the case is aseptic, or if sepsis has been cured, the fracture should be refixed in proper position for an additional period and treated by local and general means.

Locally, massage assists in the production of callus, and passive congestion is also of value. The latter method was originally introduced by Thomas many years ago, although it is frequently known as Bier's treatment. The fractured area is congested by the fixation of india-rubber bands above and below it, drawn just sufficiently tight to render the area a dusky purple colour. The congestion should be kept up on the first occasion for half an hour. It should be repeated daily, and the time increased until treatments lasting about two hours are reached. Percussion of the congested area with a heavy body, such as the head of a metal dumbbell, will sometimes assist. This combined treatment was introduced by Thomas and called by him " treatment by damming and percussion."

FIG. 216.—Walking appliance consisting of a moulded leather splint with lateral steels to a socket in the heel of the boot, applied to the case shown in Figs. 214 and 215.

The functional use of the limb in some suitable apparatus will often assist in producing bony union when this is delayed. In a fracture of the lower limb, fixation upon a walking appliance such as a caliper splint for the femur, or a double steel support with leather moulded around the fracture for the tibia, will frequently result in union. A liberal diet, open air and general hygienic conditions should be used.

By some surgeons the taking of considerable quantities of milk is thought to have a favourable influence upon delayed union.

When actual non-union is present an open operation upon the fracture will always be necessary, unless the patient's general condition contra-indicates it. For this purpose non-union may be defined as the presence of a pseud-arthrosis, the presence of loose fibrous union (particularly in bones in which there has been a great loss of substance and in bones such as the patella, in which bony union never occurs) and cases of delayed union of long duration—that is, after four to six months of treatment. The only alternative to open operation is the permanent wearing of an appliance. It must be understood, however, that in certain bones fibrous union does not lead to any appreciable loss of function. For example, a fracture of the patella, with a separation of less than an inch between the fragments and strong fibrous union, leaves a perfectly useful leg. Failure of union in the lower half of the ulna or in any part of the fibula scarcely damages the limb. In such cases operation is not indicated. The principles of operating for non-union are the same as those of operations upon fractures in general, except that some special means may have to be adopted, either to bring the ends of the bone into proper apposition or to bridge a gap in the bone by means of a graft.

**Operations upon fractures.**—The operative treatment of fractures has received very considerable impetus in recent years. So long as sepsis was an occasional event in a clean operation, operations upon simple fractures were necessarily looked upon as involving considerable risk and as only justifiable when it appeared that considerable loss of function of the limb would result unless some further correction of the displacement could be brought about. With increased safety of operating a tendency arose to operate upon fractures more freely, until some surgeons came to hold the view that the majority of fractures should be subjected to operation in order that a perfect alignment might be obtained. A mean position between these two is undoubtedly the correct one. Operations upon fractures should be reserved for cases in which reduction of a displacement is difficult and for cases of non-union and mal-union. Reduction of displacement by operation will seldom be necessary in the hands of a surgeon who is experienced in the treatment of fractures, except when it has been too long delayed. If it is felt that the reduction obtained is only partial, the necessity for operating must be judged from the probable result; if the failure to secure a perfect alignment will seriously diminish the use of the limb, operation should be decided upon without hesitation. When, however, the limb segment appears to be in good position, the fact that an X-ray photograph still shows some displacement does not necessarily indicate the advisability of operating.

Incision down to a fracture for the purpose of replacing the fragment in position will most often be indicated: (1) in spiral fractures, when the ends are interlocked; (2) in fractures in which muscle or tendon has become interposed between the fragments; (3) when reduction has been delayed for several days, and (4) in non-union.

In comminuted fracture, provided that the main fragments have been got into good alignment, the position of the smaller fragments need scarcely be considered. They are only of importance if they are likely to interfere with the movement of a neighbouring joint or with the action of some muscle.

The objects of an open operation upon a fracture are, first, to reduce the displacement, and second, to fix the ends of the bone securely together. In many cases the attainment of the first object is sufficient. As soon as the fragments have been replaced fixation upon a splint becomes simple. In other cases fixation is an essential for the success of the operation. This is more particularly so in such fractures as those of the femur, in which the pull

of the muscles tends to produce an overlapping, in those in which the muscle pulls one fragment away from the other as in the patella, and in those in which the weight of the limb pulls the lower fragment away from the upper, as in the humerus. In most cases of delayed union secure fixation of the fragments is an essential.

The bone must be widely exposed by the most accessible route. Healthy bone above and below the fracture should first be attacked and the periosteum stripped—best with a sharp rugine, so that it carries with it spicules from the surface of the bone and consequently osteoblasts. Working from the healthy bone towards the fractured ends, all the fibrous tissue and callus is then removed. It is essential to free the ends of the bone completely, so that they can be extruded from the wound. It is also necessary to remove all the deep scar tissue, because this constitutes a considerable barrier to the replacement of the fragments in their proper position.

The actual reduction of the fragments into place may be carried out by various manœuvres. In difficult cases angulation of the fragments on each other until the ends can be made to engage is the best method. When the fragments are thus engaged a gradual straightening of the limb exerts a very powerful leverage which stretches the muscles around the bone and gradually brings the fragments into proper alignment.

When a satisfactory position has been secured, it may or may not be found advisable to use some fixation apparatus. Many different mechanical appliances have been used, the principal being steel plates fixed with screws, bolts or split pins ; screws, wire (either silver or iron), plates of other metals, such as magnesium, which is absorbed, and aluminium, which is not absorbed ; sutures of silkworm gut or kangaroo tendon, etc., metal collars and bone plates and pegs, either of living bone cut from another part of the patient and constituting a bone graft, or boiled bone, prepared previously from an animal or from an amputated limb. Pegs may be made from living bone or from prepared boiled bone, or from ivory. Finally, endosteal plates or pegs have been used. These may consist of living bone, of ivory or of metal. The relative values of these methods have been thoroughly tested, both clinically and experimentally, the latter particularly by Hey Groves.

The essential when operative methods of fixation are used is that the method must be mechanically sound and the union very strong, for fixation is only really necessary in cases in which the simple use of external retentive apparatus will be insufficient. Therefore the strain upon the fixing mechanism is bound to be considerable. The presence of a foreign body in, or upon, the bone has a slight tendency to produce a reactive absorption around it. This tendency is enormously increased if even very small movements take place. Septic infection, again, is specially liable to occur if the foreign body is mobile upon the bone. If a plate is used it must be long enough to hold the bone and absolutely prevent movement. Plates with two or three screws attached to each fragment are undesirable. For a large bone, such as the femur, plates with five to seven screws in each fragment should be used. They should be fixed with screws of such a length as will enable them to penetrate the medullary canal and grip the compact bone on the opposite side. Wire is only suitable for special fractures, such as those of the patella and olecranon. Both simple screws and wire are unsuitable for fractures of the shafts of the long bones because they do not completely immobilise them.

Metal collars surrounding the fracture may fix it completely, but are undesirable because they interfere with the production of periosteal callus, which, as already seen, is important as the first stage of union. Absorbable

metal, such as magnesium, lasts insufficiently long; other metals which are not absorbable may, however, be used instead of steel.

Plates or pegs of living bone or of boiled bone are the most valuable method of fixation, particularly in cases of non-union. They may be fixed in various ways and constitute the operative method known as " bone-grafting."

The present position of the operative treatment of fractures may be summed up thus :—

The first stage of the operation must be the reduction of the fragments into proper alignment; the second stage that of fixation of the fragments together. In certain special fractures the use of wire or, instead of it, of absorbable or other sutures may be sufficient, but in fractures of the shaft of the long bones a sufficient internal fixation can only be carried out by the use of a long metal plate or of a bone graft. Metal plates should be used as little as possible, because they remain as foreign bodies, and sooner or later may give rise to septic complications. A large proportion of metal plates have sooner or later to be removed.

Bone-grafting is the operation that is usually indicated when fixation of a fracture by operation is required either for malposition or for failure of union.

**Bone-grafting.**—Until recent years the periosteum has been considered to be an important factor in the growth of bone. This view depended largely on the work of Ollier, who showed that after sub-periosteal resection the entire bone can be replaced and its intimate structure reproduced by growth from the deep surface of the periosteum.

MacEwan has put forward the opposite view—that the periosteum is merely a limiting membrane and takes no part in the development of bone tissue, and that new sub-periosteal bone grows from osteoblasts situated on the surface of the bone itself. In young people the sub-periosteal osteoblasts are abundant, because active formation of bone is occurring at this spot. In adults, however, there are few osteoblasts in this position unless some injury or inflammation has occurred. The presence, however, of any stimulus to bone production is at once followed by the development of a number of sub-periosteal osteoblasts, which probably come partly by the proliferation of the small number constantly present, and partly by growth from the openings of the canals on the bone surface. Whether the periosteum has or has not an osteogenetic function evidently depends partly upon the definition of the periosteum. If this membrane includes the osteoblastic layer which lies beneath it, then it has a power of bone formation ; it it does not, then it is a mere limiting membrane.

When the periosteum is raised with an ordinary blunt elevator it does not carry with it the osteoblastic layer. If, instead, a sharp elevator is used, superficial spicules of bone may be included with the membrane, which, raised in this way, has the power to form new bone Ollier used such sharp elevators. When the periosteum is raised as the result of an inflammatory process it again carries osteoblasts with it and produces new sub-periosteal bone.

Bone may grow from any part which contains active osteoblasts. These occur in the lining of the medullary canal, and in the interior of the Haversian canals of compact bone and all the spaces of cancellous bone. Bone which is stripped of its periosteum may, therefore, grow by the activity of the endosteal osteoblasts.

The bone may be transplanted into a new situation, where it lies either in muscles or in contact with other bone. When so transplanted from one part of an animal to another part of the same animal, the graft survives and grows

for a time. This growth occurs just as readily when the graft is denuded of periosteum as it does when the periosteum is included.

Gallie has shown that microscopic examination of bone that has been grafted in this way shows that after a week the actual bone cells have undergone necrosis, and that the contents of the Haversian canals are also dead. The main mass of the graft is in fact necrotic. Upon its surface, however, those cells which are within reach of direct nourishment from the tissue in which they lie live and grow. This growth results in a proliferation of cells of various kinds—some forming new vascular channels, some forming giant cells, whose function is to absorb the necrotic bone, some forming osteoblasts, whose function is to produce new bone. At the end of about three weeks channels are beginning to appear, cut into the bone from the surface, carrying vascular loops, and showing in their depths giant cells in the act of absorbing the bone. At the same time new bone is present upon the surface of the graft, and possibly also in the walls of these new channels that have been made. This process continues, and eventually the whole of the originally grafted bone is absorbed, being replaced, however, by the new bone produced by the activities of the surviving cells.. When the bone is grafted in this way into muscle the only bone-forming cells present are those of the graft. These carry on the replacement of the bone for a time, but eventually there is a tendency for absorption to take place, because the new bone has no function assigned to it.

If, however, such a graft is placed in contact with living bone, the activities of the surviving cells of the graft are assisted by cellular infiltration, carrying vessels, giant cells and osteoblasts from the living bone with which the graft is in contact. In this case the replacement of the original graft is carried out by a dual process—partly by the cells of the graft itself, partly by the cells invading it from the healthy bone.

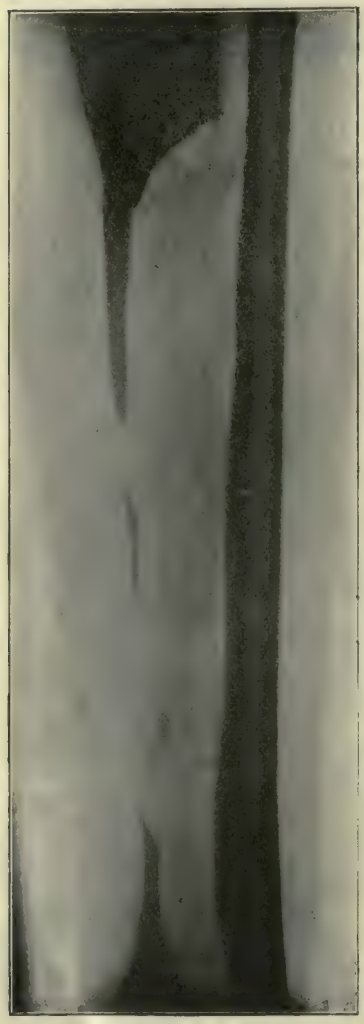
Instead of using a living graft a piece of boiled bone may be grafted into the tissues. If such boiled bone is inserted between the muscles it is slowly absorbed, and not replaced, because it carries with it no bone-forming cells. If, however, the boiled bone is fixed in contact with living bone, it is attacked by the cells of this bone and gradually invaded and replaced, so that, for example, a bone plate used to fasten together two fragments of a fracture is eventually entirely replaced, the new bone formed being completely incorporated in the substance of the fractured bone.

Bone grafts may be used for two purposes—first to form a mode of union between fragments of a bone which are in contact with each other, and second, to bridge over a gap in a bone.

For the first purpose Gallie's experiments have shown that a plate of boiled bone is just as efficient as a graft of living bone. For the second purpose the graft of living bone is superior, because it carries on its surface a number of cells which will survive and assist in the production of the bone which must eventually replace it. Nevertheless, a short gap, up to one inch or so, may be bridged with boiled bone, and this bone may be replaced by the ingrowth from its two ends, union thus resulting.

When a single bone, such as the humerus or femur, is grafted for non-union, it is best to clean and refresh the fractured ends, and to bring them into contact. The graft is then used chiefly as a means of keeping apposition between these fractured ends. For this purpose a bone plate, previously cut and boiled, may be used. If, however, it is thought that a deficient osteogenetic power is one cause of the non-union, the use of a living graft is preferable.

When a considerable section of one of a pair of bones is missing, for example, in the radius or tibia, the choice lies between shortening the other bone, and so bringing the fractured ends into contact, and bridging the gap with a graft. In most cases the second method will be preferred, because the other



GRAFT INSERTED INTO THE TIBIA FOR THE LOSS OF THE SHAFT AS THE RESULT OF OSTEOMYELITIS, IN A GIRL OF SIXTEEN.

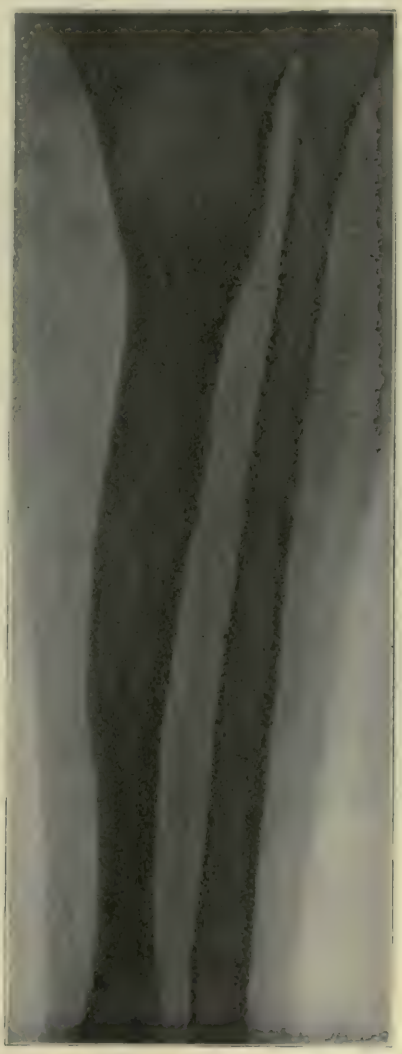
FIG. 217.—The condition of the tibia before the insertion of the graft.

FIG. 218.—Six weeks after the insertion of a graft 10 inches long taken from the crest of the opposite tibia.

entails considerable shortening of the limb and removes the support which is given by the unfractured paired bone.

A bone graft must be amply strong, must be long enough to secure a good hold upon each fragment, and must be very firmly fixed. Its ends should be fixed in the fractured portions of the bone, so that it lies in contact with freshly cut and healthy bone. Three methods of fixation are in use. In some cases

the medullary cavity of the upper and lower fragments can be opened, and the graft driven upwards and downwards into them (*intra-medullary graft*). In other cases a groove may be cut in the sides of the upper and lower fragments, the graft inlaid into this groove and fixed with sutures of kangaroo



GRAFT INSERTED INTO THE TIBIA FOR THE LOSS OF THE SHAFT AS THE RESULT OF OSTEOMYELITIS, IN A GIRL OF SIXTEEN.

FIG. 219.—Two and a half years after the insertion of the graft.

FIG. 220.—Five years after the insertion of the graft. The new tibia is becoming restored to its normal shape.

tendon or strong catgut (*inlay graft*). In other cases the graft may be laid along the side of the fragments and fixed either by sutures through holes drilled, through graft and bone, or by ivory pegs or screws (*lateral graft*).

As a rule, the first of these methods is suitable only for cases in which the fractured ends are being brought into contact.

The other methods may be used both in these cases and in cases in which a gap is being bridged. Secure fixation is essential. For this reason, in grafting such a bone as the femur or humerus, some operators prefer to use a metal plate as a secondary method of fixation. Others use bolts of metal to secure the graft in place. The development of the use of boiled bone plates and ivory screws will probably render these methods unnecessary.

Complete immobilisation of the grafted bone is essential. Fixation of the limb in plaster of Paris at the time of operation is the best method of securing this.

The bone for grafting purposes may be taken from various positions. Most commonly a portion of the shaft of the tibia is used. This may be cut with a motor saw from the crest of the tibia by two longitudinal saw-cuts. One cut is made vertically down the antero-internal surface of the tibia from three-eighths to five-eighths of an inch from the crest. The second cut is made down the external surface of the tibia three-eighths of an inch behind the crest. A graft up to about ten inches in length can thus be obtained from an adult tibia. It is suitable for any method of grafting, but for inlaying, a graft taken from the subcutaneous surface of the tibia is often preferable. Two parallel saw-cuts are made into the medulla, the portion of bone between them being lifted out. Instead of using the tibia a portion of the fibula may be taken, the whole thickness of the shaft being removed. As much as seven inches of the upper end of the fibula, including the head of the bone, has thus been removed and grafted, and has survived.

FIG. 221.—Mal-union of a fracture of the lower end of the femur. The lower fragment is displaced backwards and angulated upon the upper, so that an apparent hyper-extension of the knee is produced.

As already seen, the fate of grafted bone is to be slowly absorbed and replaced. During this process, which may occupy over a year, the graft in its new situation is not really strong. It is important that this should be realised, for the area should be protected by external splinting for from twelve to twenty-four months. In many cases a graft which bridges a gap in the bone has been fractured by slight violence many months after it has been inserted.

**Mal-union of fractures.**—A fracture is not mal-united simply because an X-ray photograph shows that the fragments are not in an ideal position. The test to be applied is the effect of the union upon the use of the limb. If union has resulted in a malformation which affects the utility of the limb, the fracture is mal-united and unless there is some other contra-indication treatment will be required. The mal-union may consist in the persistence of any of the forms of displacement that have been previously enumerated.

Mal-union in which there is overlapping of the fragments, leaving shortening of the limb, is common. It does not necessarily indicate the advisability of

operative treatment, because the improvement in use obtainable may not be commensurate with the risk which must be run in order to secure it.

Angular displacement is much more important, because it will often interfere with the function of the joints or, in the lower limb, with the use of the leg for weight-bearing. For example, a not uncommon form of mal-union in the femur is an angulation of the lower fragment upon the upper, the angle pointing backwards. An apparent hyper-extension of the knee results, which disables the patient considerably.

When treatment for mal-union is undertaken an operation is nearly always necessary. Only in cases of comparatively recent fractures, in which the callus is still soft, may it be possible to mould the bone by pressure.

Operations for mal-union are of two sorts. In some cases the essential element in the deformity may be corrected by a simple osteotomy, or by the removal of a wedge of bone. For example, mal-union of the tibia with internal rotation of the lower fragment can be corrected by a simple subcutaneous osteotomy. In other cases it is necessary to cut down on the fracture, to reconstruct it, separating the original fragments, loosening them and replacing them in proper position. Mal-union in a Pott's fracture practically always necessitates such an operation, which is carried out in this case by the removal of a small wedge from the base of the internal malleolus and by the division of the fibula at the site of the original fracture. The foot can then be wrenched into the correct position and fixed there.

Reconstruction of a fracture in such a bone as the femur is a considerable undertaking, involving a prolonged operation, much shock to the patient, and subsequent treatment lasting as long as that of the original fracture. Naturally such a proceeding is undertaken only when a very definite functional disability can be corrected by no other means.

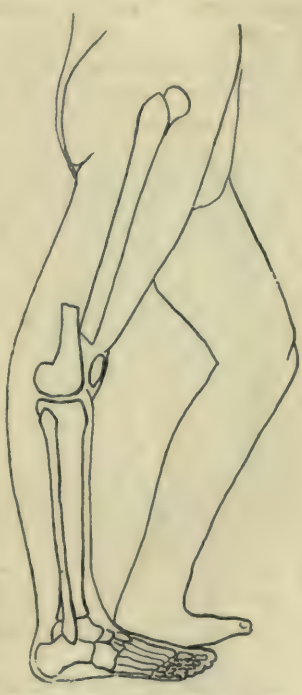


FIG. 222.—Diagram of the position of the fragments.

**Compound fractures.**—Compound fractures differ from simple ones chiefly in their liability to septic complications. If the external wound heals aseptically, the fracture once again becomes simple.

The chief object in the treatment of these fractures, therefore, is to secure early aseptic healing. In many cases a fracture is compound because one fragment of the bone has forced its way through the skin, only a small external wound resulting.

In other cases, however, the wound has been produced from without, or the bone has been forced through a considerable opening of the skin, and there is much laceration of the soft parts.

Compound fractures must be treated on the same general lines as are other wounds of the soft parts. When the patient is under treatment in a hospital soon after the injury immediate operation will usually be indicated. Such operation does not, however, necessarily involve much interference with the bone or fixation by plates or other mechanical means. Its object is to secure

cleanliness and aseptic healing. It will most often consist in an excision of all lacerated or damaged tissue, thorough cleansing of the bone, replacement of the fragments in position and fixation upon a splint, the wound being sutured or left open according to the degree of cleanliness attained.

The advisability of removing splintered fragments in a compound fracture is subject to difference of opinion. Loose fragments which are completely detached are better removed, those still attached to periosteum or muscle are best left *in situ* unless they are so contaminated with dirt that they constitute a danger of increasing sepsis. The complete removal of all splintered fragments is only justifiable if by this means asepsis can be secured with absolute certainty. The removal of fragments has been advocated in the belief that they become necrotic and constitute sequestra. This is not by any means true. They may survive, even if sepsis supervenes. They will survive if the wound remains clean. Experience has shown that in a septic compound fracture the sequestra which give most trouble are those which separate as the result of infection from the extremities of the main fragments of the bone.

When only a tiny skin puncture has been produced by one of the fragments of bone it is better simply to reduce the fracture and to fix on a splint after cleansing the skin and sealing the surface with a sterile dressing. In the case of any larger puncture an operation at the earliest possible moment is advisable.

If a compound fracture remains aseptic, union occurs in exactly the same way as in a simple fracture. If, however, the area of the bone has become infected, union is interfered with by the occurrence of osteomyelitis. Union then takes place chiefly by the production of new sub-periosteal bone. Necrosis of some portions of the fragments occurs, and one or more sequestral cavities are left between the ends of the main fragments. The pus from these cavities usually reaches the exterior through cloacæ formed at points where the periosteum has been torn. The shape and position of the sequestral cavity varies greatly, depending upon the displacement of the fragments, the extent of comminution, the extent of the damage to the periosteum, and the exact portions of the bone which have become necrotic. In most cases, however, firm union occurs, but a sinus persists, leading down to a cavity in the bone, in which the sequestra remain. Often such sequestra are enclosed and necessitate an operation for their removal. The final treatment in such a case must be upon the same lines as in a case of chronic osteomyelitis, with cavities and sequestra.

**Complications of fractures.**—A fracture may be complicated at the time of its occurrence by a simultaneous injury of a main artery or nerve. Vascular injuries are of importance chiefly in the consideration of the possible necessity of amputating the limb. Immediate involvement of the nerves does not as a rule indicate any modification in the treatment of the fracture. Later circulatory disturbances may occur, most often in fractures which are infected. Secondary hæmorrhage may be a deciding point in necessitating amputation. Venous thrombosis occasionally occurs.

Dislocation of a joint sometimes co-exists with a fracture. Many fractures, such as Pott's fracture and Colles's fracture, are really fracture-dislocations, the breaking of the bone co-existing with the displacement which alters the relative position of joint surfaces. In other cases, however, the fracture of a small process of bone, such as the coronoid process of the ulna, takes place at the same time as the dislocation occurs. In other cases, again, a complete fracture co-exists with the dislocation of the neighbouring joint—for example, a fracture of the surgical neck of the humerus may be complicated by a dislocation of the shoulder. These different groups of fracture-dislocation differ

both in origin and in treatment, and they will be separately considered under the injuries of the particular regions in which they occur.

Late involvement of nerves is not uncommon. Most frequently the musculo-spiral nerve becomes involved by enclosure in the callus in a fracture of the middle of the shaft of the humerus.

Other local complications may be due to the treatment. For example, pressure of bandages or splints produces ischæmic contracture of the forearm. Pressure upon the median nerve at the elbow may be produced by flexion of this joint employed in the reduction of a fracture of the lower end of the humerus without the fragments being first completely freed. Crutch paralysis is common as the result of the pressure of a crutch upon the musculo-spiral nerve where it leaves the axilla.

The most important general complications of fractures are those due to septic complications and such general conditions as shock and delirium tremens, which may result from any severe injury.

**Separation of epiphyses.**—The epiphyseal disc of cartilage is usually described as the point at which the growth in length of the long bones takes place. Actually there is a two-fold mode of growth. The cartilage proliferates towards the diaphysis, and the bone of the diaphysis at the same time grows into and replaces the cartilage, the latter being absorbed and then replaced by light cancellous bone which is gradually modified until the structure necessary to maintain strength has been arrived at. There results an area near the end of the diaphysis where the bone is newly formed and very light and weak. This area in a growing bone is one through which a fracture commonly occurs. The so-called separation of an epiphysis is actually, in nearly every case, a fracture through this bone close to the diaphyseal side of the epiphyseal cartilage. Only very seldom does the injury involve the cartilage itself.

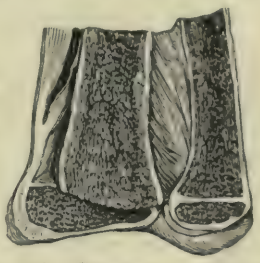


FIG. 223.—Separation of the lower epiphysis of the radius from a lad aged 16 years. The epiphyseal cartilage remains adherent to the epiphysis. (St. Bartholomew's Hospital Museum.)

Separation of epiphyses do not differ essentially from other fractures. They occur instead of fractures under certain conditions in children. Sometimes the force producing the separation is the same as that which would produce a corresponding fracture. For example, in children a separation of the lower radial epiphysis is equivalent to a Colles's fracture and may occur from falls upon the hand. In other cases the separation results from a slight strain in a particular direction. The epiphysis of the head of the femur may be displaced by a twisting strain in dancing, running or jumping. In the lower end of the humerus, fracture or separation of the epiphysis may occur under exactly similar conditions—in fact, it is often difficult to be sure whether a particular injury in this region should be classed under one or other category.

If the displacement has been completely reduced, so that the epiphysis lies in its normal relationship with the shaft, union takes place just as in any other fracture. There results, however, a transverse area in the bone, which is occupied first by fibrous callus, later by new, irregularly arranged bone. Only after some months may the normal architecture be restored—practically a scar is left across the bone. It must be remembered that an ingrowth of bone cells into the cartilage is an essential part of the growth in length of the

bone. The presence of the scar retards this ingrowth, and may interfere in this way with the growth of the bone. This interference results in a later shortening of the bone, which, however, in most cases is only trivial in amount. If, however, the reduction of the displacement has been imperfect, the ingrowth of bone cells into the cartilage may be much more seriously interfered with. The retardation of growth is then considerable—there may even be a complete arrest of growth.

The importance of such areas of growth varies in different bones. In the humerus interference with epiphyseal growth at the upper end may leave a shortened, but otherwise normal, arm. Injury of the lower end is not likely to cause much shortening, because the bone grows but little at this end. Often, however, in this region the injury is not a complete transverse one, but an oblique fracture extending from above the internal condyle into the middle of the joint; growth at the outer part of the epiphyseal line is therefore not interfered with, but growth at the inner part is retarded. A deformity of the lower end of the humerus, with an obliquity of the joint surface and consequent cubitus varus, results. Other examples of the effects of epiphyseal injuries in producing deformity will be found in the section on deformities.

## Fractures of the Bones of the Face.

**Fractures of the nasal bones.**—(See p. 715.)

**Fractures of the malar and zygoma** are only of importance from the æsthetic point of view. The chief deformity is that due to depression of one part of the bone upon the rest. Such a depression can only be reduced through a small incision. Unless the displacement is severe, the fracture will, as a rule, be better left alone.

**Fractures of the superior maxilla** are due to direct violence. Fractures of the body of the bone are uncommon, but the nasal process may be broken at the same time as the nasal bones are fractured, or the surface of the antrum may be crushed in by direct violence, or the alveolar process may be split or a portion of it broken off. In severe injuries to the face the whole upper jaw may be separated from the base of the cranium and driven backwards. Fractures of the upper jaw are usually diagnosed with ease, because of the large proportion of bone which is palpable either externally or through the mouth.

The most important point in treatment is to preserve the position of the teeth, so that they meet those of the lower jaw accurately. The treatment should, therefore, be carried out with the assistance of a dental surgeon and by means of a suitable dental splint. Union is usually rapid.

**Fractures of the lower jaw** are much more frequent than those of any other of the facial bones. The fracture most commonly occurs in the anterior part of the jaw. Fractures of the neck of the bone are comparatively rare. Double fractures involving a complete separation of one portion of the bone are more common than in any other bone. In an ordinary fracture, due to direct violence, the fissure is usually vertical or nearly vertical. It commonly extends through the mucous membrane of the mouth, so that the fracture is compound. In fractures near the middle line, the displacement is usually small, but in fractures opposite the canine tooth, or external to it, some displacement is the rule. This displacement may occur in various directions; one fragment may be elevated above the other, or displaced backwards or forwards upon the other. This displacement is probably due to the direction of the fracturing force, and not to muscular contraction. In fractures behind

the teeth the fissure is usually oblique, across the angle of the jaw, and displacement is generally absent. In fractures of the condyloid process, the whole jaw may be displaced forwards on the affected side, the small upper fragment remaining in the joint.

In most cases fractures of the jaw are easily diagnosed by the discovery of mobility, crepitus, displacement, and by the occurrence of localised pain. Only in fractures situated behind the teeth may diagnosis be difficult. A difficulty in moving the jaw or an asymmetrical movement is an important indication in these cases. By careful palpation, abnormal mobility and crepitus may be detected both in fractures of the ascending ramus and in fractures of the condyloid process.

Nearly all fractures anterior to the last molar teeth are compound, and there is a considerable liability to infection of any tooth socket through which the fracture passes and, consequently, of the bone at the site of fracture.

The most important principle in the treatment of fractures of the jaw is to make certain of securing an alignment of the teeth that will ensure their meeting the opposite teeth accurately. For this reason it is advisable that all fractures of the jaw should be treated in conjunction with a dental surgeon. As a rule the fragments will be replaced in position with the patient under an anæsthetic, and a dental model taken immediately. A suitable splint made to this model will secure perfect alignment of the teeth and jaw. The old-fashioned jaw bandage, or external jaw splint, is only suitable for use as an auxiliary method of treatment and for cases in which there is absolutely no displacement.

**Fractures of the ribs and sternum.** (See pp. 771 and 772.)

## Fractures of the Bones of the Upper Limb.

**Fractures of the clavicle.**—The usual fracture of the clavicle is situated about the middle of the shaft, and is due to indirect violence, such as a fall upon the shoulder or upon the outstretched arm. The bone breaks at its thinnest and least supported part, as the result of a bending strain. Direct violence may produce a fracture at the point struck. The inner fragment is not displaced, or at most is tilted slightly upwards. The outer end is drawn downwards, forwards, and inwards by the weight of the arm, so that the outer fragment points upwards and backwards, forming an angle above with the inner fragment, in front of which it may lie. The shoulder is shortened; the patient usually carries the point of the shoulder forwards and supports the elbow with his other hand.

If the fracture is external to the coraco-clavicular ligament, there is no displacement, and the diagnosis must be made by the discovery of a tender point and by means of an X-ray photograph. Fractures of the sternal end are rare and present no special peculiarity.

In children a greenstick fracture is not unusual, the first discovery being a deformity due to angulation or to a mass of callus.

The displacement of the fragments can be overcome by carrying the point of the shoulder upwards, outwards, and backwards; as the weight of the arm tends to reproduce the deformity, the shoulder must be maintained in this position in order that good alignment may be kept. A simple way of retaining the position is to place the patient flat in bed, with a narrow pillow behind the shoulders and the elbow supported; the shoulder then falls backward of its own accord. In cases in which it is especially important to prevent deformity this method of treatment is the best. The recumbent position should be

maintained for three weeks, the arm afterwards being kept in a sling and gently exercised. Sayre's strapping is the simplest method of ambulatory treatment. Three strips of strapping, each 4 inches wide, are cut. The first is stitched, with the adhesive side outwards, loosely around the arm at the level of the deltoid insertion. The arm is then drawn backwards and the strapping carried across the back, round the front of the thorax, and between the affected arm and the side, being fixed to that part which crosses the back. The second strip is fixed to the back of the sound shoulder, passed obliquely across the back, and under the elbow of the affected side, a slit being made to receive the olecranon. It is then brought upwards in front of the chest and fastened over the sound shoulder. The first strip draws the arm backwards; the second elevates the elbow and draws it forwards, thus levering the shoulder backwards and upwards; the third strip is carried completely round the arm and chest to fix the other two. The axilla and the palm of the hand should be padded with wool before the plaster is applied.

Fig. 224.

Fig. 225.

Fig. 226.

Figs. 224, 225, 226.—Sayre's method of treating fractured clavicle. (After Agnew.) (The third strip of strapping is not shown.)

Practically all fractures of the clavicle can be treated in one or other of these ways.

In fractures of the outer end without displacement a simple sling worn for three weeks is sufficient.

In greenstick fractures, seen sufficiently early, the deformity should be corrected by direct pressure upon the two fragments.

Complications of fractures of the clavicle are very rare, but pressure upon the brachial nerves occasionally occurs.

Non-union of the fracture is extremely rare. Mal-union is not uncommon, but is only important from the æsthetic point of view. When there is an unsightly prominence over the centre of the bone, this may be chiselled away. If the deformity is severe, an osteotomy of the bone and a fresh fixation may be desirable. Except in these cases of mal-union, operations upon fractures of the clavicle are unnecessary.

**Fractures of the scapula.**—Fracture of the body of the scapula is nearly always caused by direct violence. The line of fracture may be transverse across the infraspinous fossa, or it may cross the spine, or the fracture may be star-shaped, there being several fragments. There is usually not much

displacement, the fragments being held together by the muscles attached to the bone.

The diagnosis is made by observing that the line of the borders of the bone is irregular, by discovering crepitus on movement and by the presence of bruising.

Reduction of the fragments into position is not required, the only treatment necessary being by strapping the scapula to the chest wall and then bandaging the arm to the side, over an axillary pad. This position should be maintained for four weeks, and the arm then gently exercised. Good function results, even though the fragments are not held in perfect position.

Fracture of the acromion process is rare. It is caused by a fall or blow upon the shoulder. The outer fragment is drawn down by the pull of the deltoid muscle, the diagnosis being made by the occurrence of a tender point and of a depression produced by the displacement. It may be difficult to distinguish a fracture of the tip of the acromion from a dislocation of the acromio-clavicular joint.

The fracture is treated by raising the arm; a pad may be placed over the shoulder and a piece of strapping passed beneath the flexed elbow and made to cross over this pad, the wrist being supported in a sling.

Fracture of the coracoid process is very rare. It may result from direct violence, or from pressure exerted by the head of the humerus in a sub-coracoid dislocation. It is said that the process may be pulled off by the action of the biceps muscle. The diagnosis is made by the discovery of the local tenderness, by mobility of the process and by means of an X-ray photograph.

The arm should be kept supported in a sling with the elbow flexed and bandaged to the side, until the patient is able to begin to use the limb himself—a period of about three weeks.

Fracture of the neck of the scapula is also very rare. A true fracture of the neck extends from the suprascapular notch to below the glenoid cavity, the coracoid process being included with the glenoid cavity in the separated portion of the bone. This fracture results from a fall upon the shoulder. It is characterised by dropping of the head of the humerus together with the coracoid process, flattening of the shoulder, and prominence of the acromion. It may be treated by inserting a pad in the axilla, strapping below the elbow and over the shoulder, as for fracture of the acromion, and bandaging the arm to the side. Fixation should be maintained for four weeks.

Fractures of the glenoid cavity occur in several forms. The fissure may start in the suprascapular notch, ending below across the middle of the glenoid cavity, or the upper or lower or anterior or posterior margin of the cavity may be broken off. Diagnosis must depend upon an X-ray photograph. Fixation, with the elbow supported and the shoulder abducted, either upon an abduction splint or in plaster of Paris, is required for four weeks.

**Fractures of the head and neck of the humerus.**—Fractures of the upper end of the humerus may be divided into:—(1) Rare cases of fracture through the anatomical neck, the articular surface of the head of the bone being separated without injury to the region of the tuberosities; (2) fractures through the tuberosities, including separation of the head through this region and comminuted fractures in which the tuberosities are split; (3) fractures of the greater or lesser tuberosity; (4) separation of the upper epiphysis; and (5) fractures of the surgical neck.

1. *Fracture of the anatomical neck* is extremely rare, the few known cases having occurred chiefly in elderly people. The diagnosis must depend

upon an X-ray photograph, and the treatment upon the displacement found in the upper fragment.

2. *Fractures through the tuberosities* are due to a severe injury, usually from a direct blow upon the outer or anterior aspect of the shoulder. The head of the bone may be separated, and this separated portion may be driven into the tuberosities, splitting them vertically. In either case there will be evidence of a severe injury to the shoulder with much swelling, widening of the upper end of the humerus in the antero-posterior direction, and crepitus on movement. The actual nature of the injury will be discovered in an X-ray photograph.

These fractures should be treated with the arm in an abducted position, traction being exerted to keep the shaft and the tuberosities pulled away from the head of the bone. A straight Thomas's splint, with traction in the right-angle position, may be used. As in all fractures of the upper end of the humerus, an X-ray photograph should be taken after the fracture is fixed to determine the position of the fragments. Provided that the articular surface of the head of the bone is undamaged and has remained facing the glenoid cavity, some mobility of the joint may be expected, but the formation of new bone around the region of the tuberosities and the later supervention of osteo-arthritic changes renders it probable that in fractures in this region considerable stiffness of the joint will result. Abduction of the shoulder is advisable both because the damaged greater tuberosity is likely to be abducted by the spinati and because, by after-treatment, it is simpler to restore adduction than it is to gain abduction.

Early mobilisation of the joint is undesirable; it will probably result in some movement of the fragments upon each other, leading to an increase in the callus and consequently greater stiffness eventually. Fixation should be maintained for six weeks.

3. *Fractures of the greater tuberosity.*—This fracture is probably more frequent than is generally believed. The tuberosity is torn off by the spinati muscles, sometimes when the head of the humerus is dislocated, sometimes without dislocation. Localised pain, particularly upon attempting rotation or elevation of the arm, crepitus, and an X-ray will settle the diagnosis.

The arm should be fixed with the shoulder abducted to a right-angle and externally rotated, either upon an abduction splint or in plaster of Paris, for a period of four weeks.

Fractures of the lesser tuberosity are extremely rare.

4. *Separation of the upper epiphysis* occurs between the sixth and twentieth years. The line of separation corresponds on the inner side with the margin of the joint cavity; on the outer side the epiphysis includes the tuberosities.

The injury may or may not result in an opening of the shoulder joint. The causes are similar to those of fracture of the surgical neck. The epiphysis becomes rotated by the spinati, so that its fractured surface faces outwards. The upper end of the lower fragment is usually displaced forwards and may lie beneath the coracoid process.

The appearances somewhat resemble those of dislocation of the shoulder, the arm being shortened and abducted from the side and a prominence being present in front of the joint. Upon examination, however, this prominence will be found to be smaller than the head of the humerus, and to consist of the upper end of the shaft. The head of the humerus can be felt in its proper position, and, because of this, the prominence of the deltoid muscle is retained.

Reduction of the displacement is carried out by direct traction upon the arm under an anæsthetic, followed by abduction and rotation outwards to

Plate 4.

Fracture through the surgical neck of the humerus. (From a skiagram taken by Dr. Hugh Walsham.)

bring the lower fragment into proper alignment with the head of the bone. Fixation in an abducted and moderately externally rotated position is required, as for fracture of the surgical neck. If the fracture is completely reduced, there should be very little interference with growth of the bone. If, however, there is a persistent malformation, the arm may be considerably shortened.

5. *Fractures of the surgical neck* are the commonest fractures in the shoulder region. They may be due to direct violence, but more often result from a cross strain, in which the upper end of the bone is held by its muscles and the elbow is forced outwards or forwards. Or, when the elbow is fixed in an abducted position, a blow upon the outer side of the arm may fracture the surgical neck and drive the upper end of the shaft forwards and inwards. The latter is the usual displacement of the lower fragment, the upper fragment

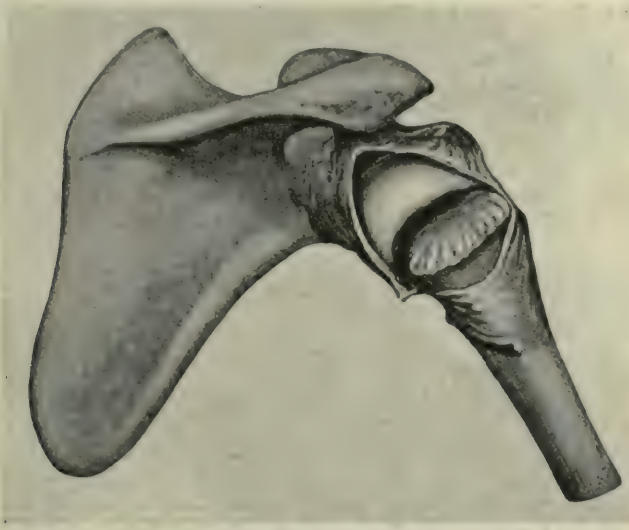


FIG. 227.—Separation of the upper epiphysis of the humerus. (St. Bartholomew's Hospital Museum.)

being abducted and externally rotated; the tilting of the upper fragment, however, is not so great as in separation of the epiphysis.

The physical signs are similar to those of separation of the epiphysis, but the prominence formed by the upper end of the lower fragment is less evident.

Reduction is carried out by traction with pressure in the axilla, the lower fragment being abducted after it has been freed by a considerable pull.

The best position for fixation of the arm is one of moderate abduction and slight forward flexion—traction is not usually required if the displacement has once been reduced, the weight of the arm constituting a sufficient pull. Fixation in plaster of Paris is the most satisfactory method, but may be irksome to the patient. Alternatively an abduction splint in which the angle can be adjusted, or a triangular cushion inserted between the arm and the side, may be used. In the latter case the forearm should lie across the front of the chest and be supported in a sling. Fixation for six weeks is required, followed by treatment by massage and exercises.

Reduction of the displacement in fractures of the upper end of the humerus may be impossible, and open operation may be necessary. For this purpose the best incision is down the anterior border of the deltoid as for an excision

of the shoulder-joint. If the fragments are completely freed and reduced at the time of the operation fixation upon a splint will usually suffice. Only in cases of fracture of the tuberosities or in comminuted fractures may suture of the fragments in place be necessary. A strong absorbable suture material, such as kangaroo tendon, is best for this purpose.

The complication of a fracture of the upper end of the humerus with a dislocation of the upper fragment is not very unusual. The two conditions may be due to the same accident, but, apart from such cases, fracture of the surgical neck may take place during an attempt at reduction of a dislocation, the head of the bone still remaining dislocated. In such a fracture dislocation the head of the humerus may be felt in an abnormal position, for example, below the coracoid process, yet the shaft of the bone takes a different line from that which would be expected in a simple dislocation. Upon moving the arm crepitus may be discovered; an X-ray examination completes the diagnosis.

Reduction of the dislocation by ordinary methods of manipulation will necessarily fail; in recent cases an attempt at reduction by traction upon the arm and pressure upon the head of the bone in the axilla may succeed; if it does not, incision on to the joint should at once be made, the head reduced by leverage, the shaft placed in proper apposition with it, and the arm treated preferably upon a Thomas's arm splint, exactly as if the case were one of a simple fracture. There should be no delay in operating upon the case. The reduction of the dislocation becomes more difficult with every twenty-four hours.

**Fractures of the shaft of the humerus.**—Under these are included any fractures below the level of the surgical neck and above the lower third of the bone. Fractures of the lower third have peculiarities in common with those directly above the condyles and through the condyles.

Fractures of the shaft of the humerus may be caused by direct violence, or by a bending or twisting strain. The bone may be broken in forcible manipulations of a stiff shoulder, particularly by external rotation. The humerus has been broken by muscular violence, generally by such a movement as that of throwing a cricket ball or striking out and missing the object. In these cases it is probable that a sudden arrest of movement by muscular action results in a fracture from a bending strain.

The displacement of the fragments varies; usually, however, in a simple fracture there is some overlapping and consequent shortening, due to the pull of the biceps and triceps muscles.

Diagnosis in a complete fracture is obvious because of the presence of abnormal mobility, deformity, shortening, and crepitus.

Reduction of the fragments into proper position is carried out by extension upon the lower fragment and manipulation. In transverse fractures reduction is simple; there is only likely to be difficulty in cases of spiral fracture in which the fragments have become in some way interlocked.

Fixation of fractures of the shaft of the humerus will be best secured by the use of a plaster of Paris case, enclosing the upper part of the thorax, the shoulder and elbow joints, the arm being held abducted about 60 degrees and slightly flexed forwards. By this means the shoulder and elbow joints are most securely fixed, and movement of the fragments upon each other is thus prevented. Methods of splinting by the use of short splints around the arm or of Gooch splinting, as well as those in which an internal or posterior angular splint is used, are defective, because they do not fix the shoulder joint.

In some cases it is difficult to maintain the correct position unless a continuous extension is kept upon the lower fragment. In these a straight

Plate 5.

Fracture through the upper third of the humerus above the insertion of the deltoid muscle. (Skiagram taken by Dr. Hugh Walsham.)

Thomas's arm splint is convenient. The fixed splint, or that with a swivel joint, at the shoulder may be used. Mobility of the shoulder may be allowed when a continuous extension is kept up, because the pull upon the muscles around the bone forces the upper fragment to come into line with the splint.

In using a Thomas's arm splint two points must be specially noted. First, that a continuous extension may, after a few days, separate the fragments from each other, so that an actual gap is left between them. If this is found to have occurred the extension must be relaxed at once for fear of inducing a failure of union. The second point is that full extension of the elbow should not be maintained for a long period—certainly not after the end of a month. By fixing a flexing iron to the splint and using extension from above the elbow, flexion of the elbow may be commenced at an early stage of treatment. This warning against the maintenance of the elbow in a fully extended position is particularly important in fractures low down in the shaft, and in fractures which are compound and have become infected. Fixation for from five to six weeks is necessary, followed by massage and exercise and the gradual resumption of use.

FIG. 228.—Fracture through the middle of the shaft of the humerus. (Skiagram taken by Dr. Hugh Walsham.)

The most important complication of fracture of the shaft of the humerus is injury to the musculo-spiral nerve, producing a paralysis of the supinator longus and supinator brevis, and of all the extensor muscles of the wrist and fingers. The triceps generally escapes, because the three nerves which supply its three heads arise from the musculo-spiral nerve above the level of the musculo-spiral groove; the outer head may, however, be paralysed. The nerve may be stretched or torn by the injury at the time that the fracture occurs, or it may come to lie partly between the fragments and be enclosed in callus. In the former case, wrist-drop follows the accident immediately; in the latter case it comes on at a later stage as union progresses.

The shaft of the humerus is a region where non-union of a fracture is by no means uncommon. This is probably due to insecure methods of splinting and to too great an extension upon the lower fragment. The use of splints which do not fix the shoulder joint allows constant movement between the two fragments in the antero-posterior and lateral planes, and the weight of the arm by itself—or assisted by an additional extension—may actually

separate the ends of the bone from each other. Non-union is often ascribed to an anatomical peculiarity—the presence of a large nutrient artery entering the bone about the middle of the shaft and running downwards into its interior. It has been thought that a fracture which injures this artery by damaging the blood supply may interfere with the production of callus. This explanation, however, will be seen to be very improbable, if we remember

FIG. 229.—Skiagram of a fracture of the lower end of the humerus with displacement of the lower fragment backwards and upwards. The lower end of the upper fragment projects in front of the joint. (Taken by Dr. Hugh Walsham.)

that the first union of the bone should be by periosteal callus nourished entirely by vessels from outside the bone.

When a fracture of the humerus is ununited at the end of six to eight weeks, fresh fixation—preferably in plaster of Paris—should be carried out, the elbow being well supported in order to force the ends of the bone together. Treatment by passive congestion may also be used, two rubber bands being placed around the arm above and below the fracture and brought out through windows in the plaster; the congestion can be kept up by tightening these bands daily for a period of from half an hour to two or three hours.

In persistent non-union an open operation is required. This operation should include a freshening of the ends of the bone, bringing them into accurate apposition and fixation, preferably by a bone graft or bone plate. In cases in which there has been much splintering, or where the ends of the bone are badly scarred from old sepsis, it is better to sacrifice length by cutting away one-half of each fragment for a distance of 1½ inches, to overlap the ends, and then fix them with a bone plate and sutures.

**Fractures of the lower end of the humerus.**—These include fractures of the lower third of the shaft, fractures through or just above the condyles, separation of the lower epiphyses, T-shaped fracture, and oblique fractures through the condyles. The last two extend into the joint.

Although these constitute a varied group of fractures, they resemble each other in that they are all amenable to the same line of treatment. They may be due either to a direct blow upon the point of the elbow, to a fall upon the hand with the elbow flexed, the radius and ulna exerting a backward pressure upon the lower end of the humerus, or to a forced hyperextension of the elbow.

Fig. 230.—Separation of lower epiphysis of humerus.

Fractures of the lower third of the shaft are commonly oblique in direction, the fissure running downwards and backwards, or downwards and forwards. The line of fracture may, however, be quite irregular. When such a fracture is due to a fall upon the hand, the lower end of the humerus is forced backwards, displaced behind the upper, and forms with it an angle pointing forwards. The lower end of the upper fragment projects in front, just above the elbow. There is a corresponding depression at the back. In a fracture through the condyles, or in a separation of the whole epiphysis, the displacement is the same, but the lower fragment is smaller.

These three classes of fracture include the majority of injuries of this region. The appearances at first sight resemble those of a dislocation of the forearm backwards, but differ from it in that the three bony points about the elbow, the two epicondyles, and the tip of the olecranon maintain their normal relationship to each other.

In some fractures, due to a fall upon the elbow, the lower fragment of the humerus is displaced forwards upon the upper, its upper end projecting in the anticubital fossa. Again the epicondyles and olecranon maintain their normal relationship.

Oblique fractures in which the fissure extends from the internal supracondylar ridge down into the centre of the joint are not uncommon. The separated internal condyle is usually driven backwards, upwards, and inwards, and the forearm rotates slightly inwards, the carrying angle at the elbow being abolished. The position of the internal epicondyle is altered, being raised

and moved backwards. As, however, the fragment carries the upper end of the ulna with it, the relationship of the internal epicondyle to the olecranon remains unaltered, but their position relative to the external epicondyle is changed.

A similar fracture separating the external condyle is not uncommon, the condyle again being displaced upwards, outwards, and backwards.

The lower epiphysis of the humerus constitutes a cup-shaped plate, which is very thin at its centre and considerably thicker at the inner and outer margins. The chief centre of ossification is that which commences in the capitellum in the third year. This forms a considerable bony mass in the cartilage covering the joint surface. Two centres of ossification occur in the two epicondyles—that in the internal appears in the fifth year, that in the

FIG. 231.—Skiagram of a fracture of the lower end of the humerus with displacement of the lower fragment in front of the upper fragment. (Taken by Dr. Hugh Walsham.)

external in the thirteenth or fourteenth year. The centre part of the trochlear surface remains cartilaginous until about the twelfth year, when a small, shallow centre of ossification commences in it. Thus it comes about that up to about the twelfth year the bony part of the epiphysis is entirely represented by a mass of bone in the capitellum. On the inner side of this the trochlear is covered only with a thin and weak layer of cartilage.

In young children an injury to the lower end of the humerus will often take the form of an oblique fracture, separating the external condyle with this epiphyseal nucleus, so that separation of the epiphysis may correspond with such an oblique fracture and involve a fissure into the joint.

Reduction of these fractures of the lower end of the humerus is of very great importance, because the injury is in close proximity to the joint and may involve it. Any persistent displacement is extremely apt to block the

movements of the joint, and an excessive formation of callus in the olecranon or coronoid fossæ will prevent full extension or full flexion by filling up these fossæ.

An anæsthetic should, as a rule, be given; the fragments can then be replaced by manipulation guided by a knowledge of the displacement present.

In all ordinary cases a routine method will suffice. The elbow should first be fully extended or even hyperextended, traction being made upon the forearm. If the lower fragment lies behind the upper this manœuvre will disengage it: a gradual flexion of the elbow to its full limit will then replace the fragments in perfect position. Occasionally the lower fragment is interlocked with the upper in some way which makes it impossible to free it. In such a case an open operation will probably be required.

The chief error in reduction is a failure to disengage the fragments. If the lower end lies behind the upper and is not set completely free, flexion of the arm will only succeed in pressing the lower end of the upper fragment against the forearm bones, possibly compressing the median nerve and brachial artery, and if the arm is fixed in this position, it will seriously endanger the nutrition of the forearm.

In fractures through one condyle reduction is simple, but the maintenance of a reduced position may be difficult. Fixation in the standard position of full flexion of the elbow with supination of the forearm will usually be successful; if it is not, an incision so that the condyle may be fixed in place by a peg will be indicated. In T-shaped fractures an operation will generally be required, in order that the two fragments into which the lower end of the humerus is separated may be sutured together.

The simplest method of fixing all these fractures in the elbow region is by means of two pieces of strapping. The forearm being flexed and supinated so that the tips of the fingers touch the shoulder, a strip of strapping 2 inches wide is laid along the back of the forearm and the back of the wrist, and brought down across the back of the shoulder. The second piece of strapping encircles the arm and forearm at the level of the insertion of the deltoid. The arm, thus strapped, may be simply supported in a sling.

Reduction and fixation of these fractures should always be followed by the taking of a stereoscopic X-ray photograph to determine whether the bones are in correct position. A stereoscopic photograph is necessary because, owing to the flexed position, an X-ray can only be taken in one plane.

The fully flexed position should be maintained for three weeks. At the end of this time, union is sufficiently firm to prevent the fragment becoming altered in position by a slight strain. The forearm should now be gradually dropped by suspension in a wrist sling until the end of six weeks. After that time the arm may be left free and used actively. Massage and early movement are much advocated for these fractures, but, except in the hands of a masseur who specialises in fractures and is particularly gentle, this method of treatment involves considerable risk. Massage must be very gentle and comparatively superficial, aiming at producing the absorption of effusion, and not at the production of additional callus. Movements must be gentle and active, being carried out through a small range and entirely by the patient's own efforts. If movement is forced during the first three weeks, a displacement of the fragments is probable. After three weeks, forcing of movement will often lead to the production of excessive callus or to the growth of bone in the muscles around the joint (*myositis ossificans*). The latter condition is more common after fractures and dislocations in the

neighbourhood of the elbow than in any other region. It is most often ascribable directly to treatment by forced movements (see p. 206).

In children, in whom a large proportion of these fractures occur, the restoration of movement may safely be left to the child's own effort. If the fragments have been well reduced and maintained in place, and if active movements have been commenced after three weeks, a practically full return of mobility may take place within three months. On the other hand, in bad fractures it is often upwards of a year before a full range of movement is restored. A slight deficiency in full extension is not uncommon even in fractures which give otherwise perfect results. Cubitus varus deformity is usually due to a fracture in this region of the humerus. It results either from a failure of reduction of the original fracture or from a partial or complete arrest of growth at the inner half of the epiphyseal line, following the separation of part or of the whole of the epiphysis.

Fractures of the internal epicondyle are not very uncommon, occurring either as a single injury or in association with dislocation of the elbow. There is usually little displacement of the fragment, the chief symptom being localised pain. The arm should be fixed in full flexion, so as to relax the muscles attached to the condyle, after-treatment being adopted as in other fractures of the lower end of the humerus.

FIG. 232.—Fracture of olecranon. (Liston's Surgery.)

**Fractures of the upper ends of the radius and ulna.**—A fracture of the *olecranon* may occur in people of any age, usually from a fall upon the point of the elbow. It is probable that the bone is broken by a forcible traction of the triceps, levering the tip of the olecranon away from the ulna shaft over the articular surface of the humerus, which acts as a wedge. This mechanism produces a transverse fracture of the bone extending into the elbow-joint, the proximal fragment being drawn up by the triceps to an extent which varies according to the amount of laceration of the capsule and aponeurosis around. The bone may be broken in a similar way in forcible manipulations to flex a stiff elbow-joint. Direct violence is more likely to produce a fissured or starred fracture, the olecranon being comminuted.

In cases in which the separation is considerable the diagnosis is easily made by the discovery of a gap in the olecranon into which the finger can be inserted. When, however, there is much effusion of blood and when the proximal fragment is small, the latter may escape detection. In doubtful cases, therefore, a lateral X-ray photograph should be taken. The separated piece of bone can be generally brought into apposition with the rest of the ulna by full extension of the elbow, accompanied by downward pressure, exerted by transverse strapping, upon the upper fragment. If by this means approximation is impossible, an operation should be undertaken. The latter consists in an incision down the back of the elbow and fixation of the fragments together, either with wire or with an absorbable suture, such as kangaroo tendon. Often a suture through the aponeurosis and around the bone will be sufficient. The elbow should be fixed in the fully extended position for four weeks, and then slowly flexed. Only in cases in which fixation by wire has been carried out may earlier flexion be allowed. If there is difficulty in

securing a return of full flexion, the wrist should be supported by a cuff which is attached to a leather collar around the neck (collar-and-cuff sling). If this sling is kept constantly tight, the continuous pressure exerted will rapidly flex the elbow joint. Massage and the use of active movements completes the restoration of function.

Fibrous union is common after this fracture. When the gap is small, little or no disability should result. When the gap is large, active extension of the elbow is weak or impossible. In the latter case, an operation for the removal of the intermediate fibrous tissue and suture of the bone is indicated.

Fracture of the *coronoid process* is very rare, except as an accompaniment of dislocation of the ulna backwards. It is caused by direct pressure of the process against the lower end of the humerus, or by the fixation of the process by the brachialis anticus muscle whilst the elbow is hyper-extended. This fracture should be suspected when a dislocated elbow can be reduced easily but the dislocation recurs if full extension of the elbow is allowed. The actual discovery of the fracture will usually be made in an X-ray photograph, but it may be possible to feel the loose fragment.

Fig. 233.—Collar-and-cuff sling.

Treatment consists in immobilisation of the joint in a position of flexion after the dislocation has been reduced. The exact degree of flexion required to maintain the best position of the fragment can only be ascertained by X-ray examination. Immobilisation in this position should be kept up for one month, massage and active exercises then being employed.

Fractures of the *head and the neck of the radius* are comparatively rare accidents, due usually to a fall upon the forearm or elbow; not infrequently they result from falls whilst riding. They may be associated with injury of the lower extremity of the humerus or with a fracture of the ulna, or they may exist alone. The exact mechanism of the production of these fractures is not understood.

Local swelling and tenderness over the head and neck of the radius, limitation of full extension of the elbow, and of pronation and supination, are the chief physical signs. The actual diagnosis will be made by an X-ray photograph.

When the head of the bone is broken, a small piece is usually separated by a fissure which extends into the joint; this piece may lie within the orbicular ligament, there being little or no displacement, or it may have been driven out of the ligament. In fractures of the neck, the lower fragment may be displaced forwards or backwards in relation to the upper. When there is a piece detached from the head, it will often be impossible to get it into position, and it may be necessary to remove it. In other displacements the fragments

can, as a rule, be got into satisfactory position by traction upon the forearm, manipulation of the fragments, and full flexion of the joint.

The elbow should be maintained fully flexed in the supinated position for three weeks. Movement should then be restored chiefly by the use of active exercise. There is commonly some permanent limitation of extension of the elbow, and of pronation and supination.

**Fractures of the shaft of the radius and ulna.**—A fracture of one or of both bones may result either from direct violence or from a fall upon the hand or forearm.

When both bones are broken almost any displacement may occur, in accordance with the direction of the external violence. Overlapping, angulation, and rotatory deformity all occur. When only one bone is broken there is not much tendency for the fragments to overlap, but the lower fragment is often angulated with the upper or, in the case of the radius, axially rotated upon it. A greenstick fracture of one or of both bones is not uncommon in children; the direction of angulation depends upon the direction of the force which produces the fracture.

In a complete fracture of both bones the diagnosis is simple, localised pain, deformity, abnormal mobility and crepitus all being present. In a fracture of one bone the diagnosis may be more difficult, because the support of the parallel bone leaves a much greater stability in the forearm. Slight angular deformity, localised pain and tenderness at the seat of fracture, and pain and crepitus on attempting to rotate the forearm may all assist. As the ulna is palpable throughout its length, a fracture of its shaft can usually be felt. In the case of the radius the bone cannot be felt easily, but mobility of the fragments on each other can usually be detected, and if the lower end be grasped and gently rotated pain and crepitus is elicited; at the same time it may be found that the head of the bone fails to move with the lower end. A greenstick fracture is easily diagnosed by the discovery of an angular deformity with pain at the site of the bending. A rickety deformity of the forearm is the only condition that can give rise to difficulty; in this, however, the condition should be painless.

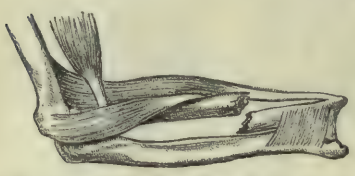


FIG. 234.—Fracture of the shaft of the radius showing the upper fragment supinated, the lower pronated. (After Gray.)

The forearm differs from all other segments of the limbs in the occurrence of the rotatory movement of pronation and supination. In this movement the ulna remains stationary, the head of the radius rotates upon an axis which is represented by the shaft of the bone, and the lower end moves around the circumference of a semicircle the centre of which is situated in the lower end of the ulna. In the adult the radius of this circle measures about two inches; in the fully supinated position the lower end of the radius lies on the outer side of the ulna; in the fully pronated position it has moved completely across to the inner side. The whole length of the ulna can be felt and the position of its fragments thus determined; the lower end of the radius can also be easily palpated; but the upper end of this bone is deeply situated and is devoid of bony points from the position of which its degree of rotation can be determined. Moreover, it is not even possible by means of an X-ray photograph to determine whether the upper end of the radius is pronated or supinated. It is therefore necessary to determine this point by considering the anatomical arrangement and the action of the muscles. The deep situation

57 H 8

Plate 6.

Skiagram of a greenstick fracture of the radius and ulna in a rickety child.
(Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

of the upper half of the radius and the impossibility of holding it by any splint or appliance renders it essential to determine its exact position, because the lower end of the bone must be brought into proper line with the upper.

If the fracture is above the insertion of the pronator radii teres, the upper fragment will be fully supinated by the action of the biceps; if the fracture is below the insertion of the pronator, it is commonly taught that the upper fragment will be pronated by this muscle. This is not in accordance with the facts. Whatever the level of the fracture in the shaft of the radius, the upper fragment tends to be fully supinated, or almost fully supinated. Therefore it is a safe rule that, in attempting to reduce the fragments into position, full supination should be aimed at. This position has two additional advantages—first, that it secures a wide space between the radius and ulna and so lessens the liability to synostosis between the bones, and second, that in after-treatment it is much easier to restore pronation than to restore supination.

In fractures of the upper half of the shaft the lower fragment of the radius is pronated by the action of the pronator teres and pronator quadratus. The pull of the first-named muscle also tends to angulate the lower fragment with the upper.

Reduction of the fragments into position must be made by traction upon the wrist and manipulation of the fragments whilst the patient is under an anæsthetic. It may be difficult because of interlocking of the ends of the bone or the interposition of muscle.

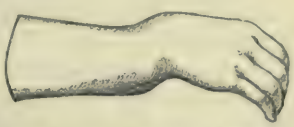


FIG. 235. — Colles's fracture. (St. Bartholomew's Hospital Museum.)

Fixation is best made with the elbow at a right angle and the forearm fully supinated, the wrist being extended. The best method of fixation is by enclosure of the wrist, forearm, and lower half of the arm in plaster of Paris. A layer of cotton wool firmly bandaged should be enclosed in the plaster in order that the necessary pressure may be evenly distributed.

If for any reason the arm cannot be fixed in plaster of Paris, a posterior angular splint and an anterior forearm splint may be used.

In compound fractures necessitating access to the wound a straight Thomas's splint, with the ring against the axilla and extension upon the wrist or hand, or a right-angled skeleton splint may be used.

Fixation for one month, followed by gentle massage and exercise, is required.

The middle of the shaft of the ulna is sometimes slow to unite firmly, and an angular deformity may arise after the plaster or splint has been removed. If any such tendency appears, a posterior supporting splint must be worn for a considerably longer period.

Ischæmic paralysis is particularly common after fractures in the region of the elbow and forearm. It is ascribed to undue pressure exerted by the splint. It nearly always follows the use of the internal angular splint, and most often the fragments have not been successfully reduced into position. There is no evidence that a moderate uniform pressure upon the forearm such as is exerted by a plaster of Paris case has any tendency to produce ischæmia.

**Fracture of the lower end of the radius (Colles's fracture).**—A transverse fracture of the radius within an inch of the articular surface is known as Colles's fracture. It is one of the commonest of injuries, and is due generally to a fall upon the hand with the wrist in the extended position. The lower fragment of the bone is displaced on to the dorsal surface, and is tilted so that

the articular surface becomes oblique, pointing downwards and backwards. The carpus is carried with the lower fragment. The styloid process of the ulna may be separated, or the internal lateral ligament of the wrist joint may be torn.

In severe injuries the lower fragment may be comminuted, the inter-articular fibro-cartilage may be torn, or the carpus may be damaged. In the latter the most frequent injury is a fracture of the scaphoid.

In a typical Colles's fracture the deformity is very characteristic, the lower fragment of the radius and the carpus forming a prominence upon the back of the wrist, the lower end of the upper fragment and the ulna forming a prominence on the front of the wrist. The back of the forearm and of the hand are thus not in the same straight line. The curve has been likened to that of a table fork.

Two less common injuries may be confused with Colles's fracture. In a transverse fracture of the radius and ulna close above the wrist and in a dorsal dislocation of the wrist joint the deformity is similar, but in the former the styloid processes of both radius and ulna are displaced backwards, together with the carpus. In the latter both the styloid processes are displaced forwards in relation to the carpus and hand. In Colles's fracture the styloid process of the radius goes backwards, that of the ulna forwards. When the styloid process of the ulna is fractured or the internal lateral ligament torn, there is a radial deviation of the hand. This is usual, but not invariable, in Colles's fracture.

Colles's fracture occurs at all ages, from youth to old age. In children and adolescence the line of fracture is close above the lower epiphyseal line of the radius; the fracture, therefore, becomes a separation of the lower epiphysis. It does not, however, differ in any way from the Colles's fracture of older people.

Very rarely a fracture of this part of the radius occurs with a displacement of the lower fragment forwards. This has been called a "reversed Colles."

Complete reduction of the displacement in a Colles's fracture is of the utmost importance. Considerable discussion has taken place as to the importance of using massage and movements at an early stage in the treatment of this fracture. Although a short period of immobilisation with early active use undoubtedly greatly improves the prognosis, neither this nor any other method of mechanical treatment can produce a good result in a case in which the fragments have been left in malposition. An anæsthetic is invariably required, and should be used unless the general condition of the patient absolutely contra-indicates it. The difficulty in reduction is due to the fact that in a large proportion of cases the posterior edge of the upper fragment of the radius is impacted into the cancellous tissue of the lower fragment. Until it has been disimpacted, reduction into good position is impossible.

The best method of reducing the displacement is the following:—The surgeon stands on the outside of the arm, with the forearm pronated, and grasps the shaft of the radius with the thumb and finger of one hand, the lower fragment of the radius, close above the wrist, with the thumb and finger of the other hand. If the fracture is in the right arm, the left hand should grasp the shaft; the right hand should grasp the lower fragment. The lower fragment is then forcibly hyper-extended upon the upper, increasing the deformity. This movement should be carried out until the lower fragment can be felt to be quite free and mobile. Strong traction should then be made upon it whilst it is brought round into the flexed position sufficiently far to make sure that the deformity is fully corrected, or even over-corrected. At

Plate 7

Colles's fracture, side view, showing displacement upwards and backwards.
(Skiagram taken by Dr. Hugh Walsham.)

the same time, the hand is displaced towards the ulnar side in order to reduce the radial deviation.

In this method of reduction the object of the first movement is to disimpact the fragments; it is much more simple and satisfactory than the others that are commonly advocated—namely, reduction by direct pressure forwards on

FIG. 236.—Colles's fracture, antero-posterior view. (Skiagram taken by Dr. Hugh Walsham.)

the lower fragment, or by traction upon the hand, which is grasped as in shaking hands.

When the wrist has been fully flexed and adducted towards the ulnar side, the deformity may appear to be corrected, even though the fragment is not completely replaced. A careful examination is required to make sure that reduction is complete. The three points that require to be noticed are, first, that the concavity which exists in the front of the radius is complete right down to its lower end; second, that the styloid processes of the radius and

ulna are in their proper positions; and, third, that the radial deviation of the hand has been corrected and that there is no longer a depression on the inner side of the wrist below the ulnar styloid process. In examining for these three points a comparison should be made with the other hand.

In most cases, when a Colles's fracture has once been fully reduced, there is little or no tendency for the deformity to recur unless the limb is subjected to further violence. If, however, massage and movements are carelessly carried out, a recurrence of the deformity may easily take place.

A simple retentive splint should therefore be used. The simplest method is the use of two metal gutter splints, one placed anteriorly and the other posteriorly. Under the anterior splint a special pad is introduced to fit into the concavity which exists in the lower end of the shaft of the radius, a second pad being inserted in the palm of the hand. In the posterior splint a small pad is inserted so that it presses upon the dorsal surface of the lower fragment. It is unnecessary to bandage the splints very tightly, and fixation of the elbow is not required.

The reduction and fixation of a separation of the lower epiphysis is carried out on exactly similar lines.

The use of massage and early movement is undoubtedly very valuable, but should never be left to the unsupervised care of a masseuse. The first object is to prevent adhesion of the posterior tendons to the bone at the point where they pass over the fracture. This can be readily accomplished by gentle massage whilst the hand lies upon a splint or pillow, with movements of all the joints of the fingers and thumb. If the patient can be induced to do it, these movements should be carried out actively, but passive mobilisation of the fingers can do no harm provided that the wrist is supported; faradic stimulation of the muscles is a useful accessory. This gentle movement of the fingers should constitute the treatment for the first week; then small active movements in the wrist joint itself—the fractured area being supported at the time—may be carried out. Only after a fortnight should these movements become larger in range and pronation and supination be added. At the end of a fortnight the splint can usually be omitted and light use of the hand allowed. Attempts to force movements which are absent should be deferred until the end of a month. Pronation and supination is practically always the last movement to return.

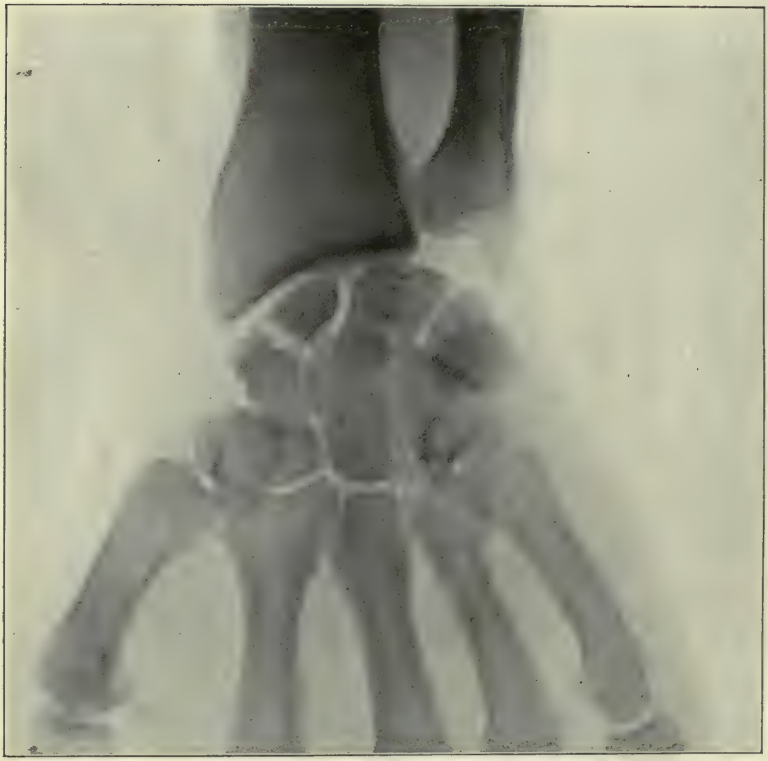
Non-union of a Colles's fracture is practically unknown. Malunion is very common. If the hand is functionally useful and there is no pain, it is best to leave the condition alone, although in young people operative treatment may be advised for æsthetic reasons. If there is pain or functional disability, an operation should be undertaken. Up to three or four weeks, manual refracture may be carried out, the fragments being replaced in proper position. After this time an osteotomy is required.

The latter should be carried out through a fairly wide incision along the line of the supinator longus tendon. The radial artery and nerve and the short thumb muscles must all be carefully avoided during the operation. A good exposure is therefore necessary.

In slight deformities a simple osteotomy may be sufficient. In many cases, however, the removal of a wedge with its base in front will be required. After an osteotomy, fixation of the forearm and wrist in plaster of Paris for a fortnight at least is desirable; there is a much greater tendency to displacement of the fragments after an osteotomy than after reduction of a recent Colles's fracture.

Other fractures of the lower end of the radius may occur. The most

Plate 8.



Fracture of the carpal scaphoid. (Skiagram taken by Dr. Hugh Walsham.)

frequent is a fissure extending from the joint surface upwards and outwards to the outer side of the shaft, or upwards and inwards, separating off a small fragment, including the articular surface of the inferior radio-ulnar joint. These fractures are frequent as the result of an injury sustained from a back-fire in starting a car, but the latter injury may equally result in a Colles's fracture, a fracture of both bones of the forearm, or an injury of the carpus. These fissures in the lower articular surface of the radius are not usually accompanied by any displacement. They require a short period of rest (fourteen days) and treatment by massage and gentle exercises.

**Injuries of the carpus.**—Any one of the carpal bones may be fractured, either by direct injury or by a fall upon the hand. In most cases the diagnosis can only be made by an X-ray photograph, the suspicion of the presence of a fracture arising from the existence of localised pain and tenderness.

Fracture of the scaphoid is the commonest carpal injury and presents definite clinical characteristics. It is usually due to a fall upon the hand, and is characterised by local pain through the radial side of the wrist immediately below the styloid process of the radius. Movements of extension and radial abduction of the wrist are specially limited. Union by bone does not take place, and in untreated cases considerable mobility between the fragments remains.

In old-standing cases this movement may give rise to a feeling of insecurity of grip, a sudden little stab of pain sometimes leading the patient to let go suddenly of any object held. The presence of such symptoms with the limitation of extension and radial abduction should lead to the suspicion that an old fracture of the scaphoid may be present.

In recent cases the hand should be fixed upon a splint with the wrist fully extended for three weeks, fingers and thumb being used actively during this time.

In old-standing cases, if there is considerable functional disability, this can usually be cured by removal of the proximal fragment of the bone.

Dislocation forwards of the semilunar is a second not uncommon injury in the carpus due to a fall upon the hand in the extended position, or to a back-fire from a motor car. The semilunar is probably shot forwards by a forcible hyperextension of the wrist. It may be felt lying deeply under the flexor tendons on the anterior surface of the wrist, level with the tips of the styloid processes. The wrist movements and the use of the fingers may be painful.

An X-ray photograph in a lateral view shows the bone lying in front of the wrist joint, usually with its concave surface directed towards the palmar aspect.

The only satisfactory treatment is by excision of the displaced bone through an anterior incision a little to the ulnar side of the middle line of the front of the wrist. The long flexor tendons must be lifted towards the radial side, when the semilunar can be found lying deep to them, and covered only by the posterior layer of their synovial sheath.

A third characteristic injury in the carpus is mid-carpal fracture dislocation, also due to a fall upon the hand. In this injury the scaphoid is fractured; its proximal fragment and the semilunar remain in their normal relationship with the radius; the rest of the carpus beyond them is displaced on to the dorsal aspect. There is thus a prominence over the middle of the back of the carpus formed by the head of the os magnum. In most cases this injury has been discovered only after an interval. The possibility of complete reduction at an early stage is therefore not determined. The most satis-

factory treatment in old-standing cases is excision of the semilunar and of the proximal part of the scaphoid.

**Fractures of the metacarpus.**—Fractures of the metacarpal bones are

FIG. 237.—Fracture of the second and third metacarpal bones. (From a skiagram taken by Dr. Hugh Walsham.)

common, being due usually to direct violence. In simple fractures the displacement is usually slight, unless the fracture is through the neck of the bone. In the latter case the lower fragment is often angulated upon the upper with a concavity towards the palm, so that the prominent knuckle

disappears from the dorsal aspect of the hand. If there is displacement, reduction must be made by traction and manipulation.

The simplest method of splinting is by the insertion of a rolled bandage into the palm, the thumb grasping the roll and the fingers being bandaged over it. If this method does not keep the fragments in position a hoop fixed to the forearm by plaster of Paris may be spread out beyond the fingers and extension made upon each of the fingers to this.

Bennett's fracture is a fissure extending through the base of the metacarpal bone of the thumb, separating the palmar surface and allowing the distal fragment to become displaced on to the dorsum. It can be reduced by traction, and is best maintained in position by making a small plaster of Paris splint.

**Fractures of the phalanges.**—These are usually caused by direct violence. If the fracture is complete it is obvious, because of the deformity and abnormal mobility. The displacement can be reduced by traction, and fixation can be maintained upon a finger splint, which extends from the middle of the palm to the tip of the finger. A malleable splint of aluminium is most convenient; it can be bent so as to maintain the finger in any degree of flexion required. Commonly, a slightly flexed position of the joints is most satisfactory.

Small fissures extending obliquely across one half of the base of the phalanx into the joint are not unusual, and commonly escape notice, giving rise later to a chronic, painful thickening around the joint. If such an injury is discovered early, it should be splinted for ten days to secure bony union. If no splint has been used union is often fibrous. A period of rest upon the splint will generally abolish the pain. If it does not, it may be advisable either to remove the fragment, if it is a very small one, or to refresh its surface and try to secure bony union if it is of considerable size.

## Fractures of the Bones of the Lower Limb.

**Fractures of the pelvis.**—Fractures of the pelvis result from severe violence, such as a crushing force or a fall from a considerable distance. In the latter case the fracture may be produced by pressure transmitted through the neck of the femur and the acetabulum; or there may be a direct injury to the back of the pelvis or to the region of the pubic symphysis. Many varieties of fractures occur, from cases in which quite a small piece of bone is broken off the crest of the ilium to instances of comminution of the entire pelvis. They are usually divided into those in which the pelvic ring is broken right through and those in which there is an isolated fracture of some particular part of the pelvis.

The pelvic ring is most likely to be broken by a crushing force or by a fall from a considerable distance. The most frequent injury is a double fracture in which the rami of the os pubis and ischium are broken in front and the ilium is fractured in a vertical direction a short distance external to the sacro-iliac joint. This condition may occur on one side only or may be bilateral. In a unilateral fracture the separated side of the pelvis is usually drawn up, so that the sacrum becomes oblique in its relationship with the transverse pelvic axis. If it is allowed to unite in this position, a severe fixed scoliosis will result. If the fracture is bilateral, the pubic symphysis will probably be driven inwards by the force producing the fracture. In more extensive comminuted fractures the fissures may run in any direction and the displacement vary very greatly. The pubic symphysis may be torn through so that a finger can be inserted between the pubic bones.

In fractures due to a fall on the hip a fissure may be produced extending

through the acetabulum, or the head of the femur may be driven right through the acetabulum, which is comminuted.

In the second group of fractures (those of isolated portions of the bone) are included fractures of a portion of the crest of the ilium, fractures of the rim of the acetabulum, which may occur with dislocation of the hip, and, rarely, isolated fractures of the rami of the os pubis and ischium.

Complications due to injury of the viscera are frequent in severe fractures of the pelvis—rupture of the bladder and laceration of the urethra being the most frequent. Rupture of the bladder probably results from the injury which produces the fracture, rather than from direct injury by the fragment of bone. Rupture of the urethra usually occurs in the membranous part, and is due to tearing by the displaced pubic arch. Injury of other abdominal

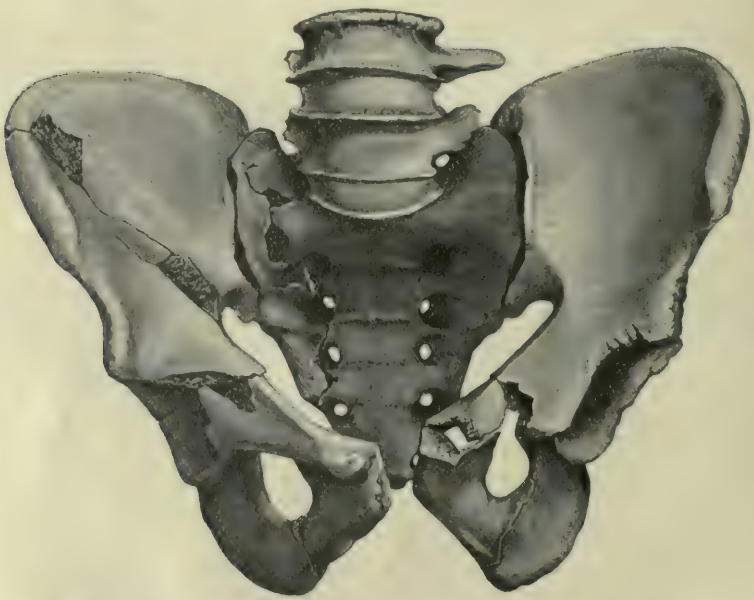


Fig. 238.—Fracture of the pelvis. (St. Bartholomew's Hospital Museum.)

or pelvic viscera and of the iliac vessels also occasionally occur. Injury of the nerves is exceptional.

Fracture of the pelvis can usually be diagnosed upon clinical grounds if there is any displacement of the fragments of the bone. A careful palpation of the subcutaneous parts of the bone—that is, the sacrum, the crest of the ilium, the iliac spines, the pubic symphysis, and rami of the os pubis and ischium —will determine whether there is any variation from their normal relationship, any localised tenderness upon the bone, or any feeling of crepitus and abnormal mobility. Such a severe injury is naturally accompanied by much shock. It is, therefore, as well not to put the patient to any considerable discomfort in endeavouring to diagnose the fracture for certain in the first twenty-four hours. An investigation for visceral complications and treatment of these must be undertaken immediately, but the fixation of the fracture may be deferred until shock has passed off.

The method of treatment must vary greatly according to the nature of the fracture. When an isolated piece of bone has been broken off and displaced

it may be possible to reduce it into position and fix it, either by pads and strapping or by enclosing the pelvis in a case of plaster of Paris. If reduction of such a fragment of bone is impossible, an operation to fix it in position should be undertaken if a persistent displacement would lead to any disability —for example, if the fracture separates the anterior superior spine of the ilium.

When the fracture is more severe and involves a separation of the pelvic ring into two parts, the first endeavour should be to get all the palpable portions of the pelvis symmetrical—that is, the lumbar spine being vertical, the crests of the ilia should be brought to the same level and the pubic rami on the two sides into their normal positions. The simplest method of attempting to accomplish this is to apply an extension upon both lower limbs, to keep the hips widely

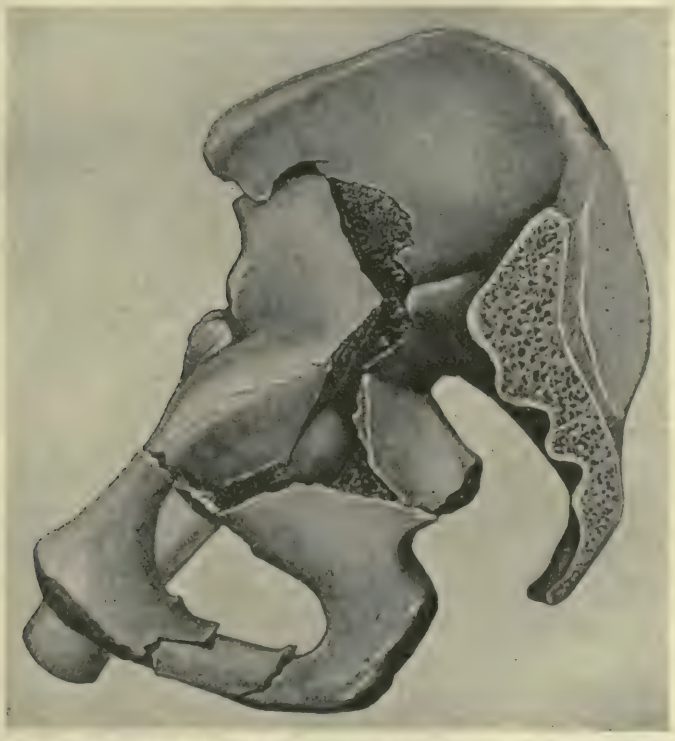


FIG. 239.—Fracture of the pelvis through the acetabulum. (St. Bartholomew's Hospital Museum.)

abducted, and to tip up the foot of the bed, so that the patient's weight constitutes a counter-extension. By adjustment of the weight on the two limbs it should be possible to make the pelvis symmetrical. Then lateral pressure can be secured, either by firm strapping or by fixation in plaster of Paris.

If there are accompanying external wounds, or if injury of the bladder or urethra has necessitated drainage, the position suggested can be obtained upon a Sinclair net bed, dressings being thus facilitated.

In a fracture of the acetabular margin an extension upon the limb is necessary in order to prevent too great a pressure of the head of the femur against the acetabulum. If the head of the femur has been driven through the acetabulum an attempt should be made to pull it out whilst the patient is anæsthetised, and an extension should be kept up afterwards, the position

being carefully regulated, because ankylosis of the hip is probable. A period of at least ten to twelve weeks should elapse before a patient with a complete fracture of the pelvis is allowed to walk.

Fracture of the sacrum as an isolated injury is extremely rare. A true fracture of the coccyx is also very uncommon, but an injury in which the coccyx either becomes mobile upon the sacrum or is dislocated forwards is a fairly frequent result of a fall in the sitting position. It may give rise to persistent pain (coccydynia), for the relief of which excision of the coccyx may be necessary.

**Fractures of the upper end of the femur.**—Fractures of the upper end of the femur may be divided into intracapsular fractures of the neck, extracapsular fractures of the neck, comminuted fracture of the trochanteric region, isolated fractures of the trochanter, and separation of the epiphysis of the head.

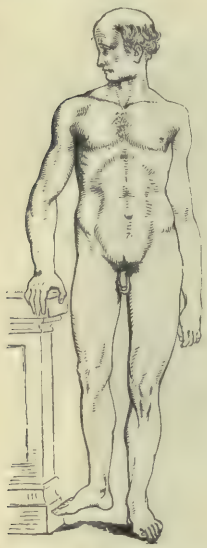


FIG. 240. — Extracapsular fracture of the neck of the femur. (See note, p. 618.)

By an intracapsular fracture is meant a fracture close up to the articular surface of the head, so that the line of separation falls entirely within the capsule and the head is left loose within the joint, with no attachment except the ligamentum teres. This injury occurs in people of all ages, but more commonly in the old. In the latter it may be due to a very slight accident, such as a simple trip and fall from the standing position. It is a mistake, however, to think that intracapsular fractures are confined to the aged or that extracapsular fractures are more frequent than intracapsular fractures in young people. The true difference is rather in the nature and severity of the injury.

An extracapsular fracture results from a severe injury, and usually from a direct blow received on the trochanter. An intracapsular fracture results from a much less severe injury, the fracture probably being produced by a twisting strain.

In children and adolescents injuries of the neck of the femur are not uncommon; either a fracture or a separation of the epiphysis may occur. The relative frequency of these two injuries is disputed. The violence producing fractures of the neck or separation of the epiphysis in children is often very slight, and in the majority of cases the injury does not produce an immediate complete displacement, so that it escapes discovery at the time, giving rise later to a coxa vara deformity. These injuries and their relationship to coxa vara will be found described in the section on deformities. In the opinion of the author, in children under the age of five or six, a fracture generally takes place; in children over this age, a separation of the epiphysis.

Fractures of the neck of the femur are either impacted or unimpacted. The nature of the impaction varies. Most often in an intracapsular fracture the posterior and inferior border of the distal fragment is impacted into the head of the bone. In extracapsular fractures the posterior inferior border of the proximal fragment or the whole of the proximal fragment is impacted into the trochanteric region. In the latter case this portion of the femur may be extensively comminuted.

The diagnosis of fractures of the neck of the femur is sometimes difficult

until an X-ray photograph has been taken, the signs being comparatively slight. This is particularly true in old people. The early diagnosis of these fractures is very important, so that an X-ray examination should never be omitted in a hip injury. In a typical case of intracapsular fracture the patient is unable to get up from the ground or bear weight upon the limb. The limb lies externally rotated, and movement of the hip joint is painful and resisted. Measurement shows shortening small in amount, 1 inch being about the maximum, and investigation of Bryant's triangle shows that this shortening is above the great trochanter. Rotation of the limb should be very carefully tested. If the fracture is impacted the head of the femur rotates with the great trochanter, but the latter is generally situated further back than upon the sound side. If the fracture is not impacted the great trochanter rotates separately from the head, its rotation being through an arc of a smaller circle than upon the opposite side. Crepitus may be felt when the limb is rotated. Great care should be used to employ no force, as it is undesirable to disimpact an impacted fracture. The picture may vary very greatly from this typical one. Thus a patient may be able to walk upon the limb for some time after the injury. There may be no shortening at first, and there may be inversion instead of eversion. If a fracture has been missed and the patient allowed either to walk upon the limb or to sit, the shaft of the bone generally moves upwards, shortening appearing and the hip becoming flexed and adducted.

In an extracapsular fracture the injury is more severe and accompanied by much external bruising. There is eversion of the limb and shortening and elevation of the trochanter. Signs of impaction or its absence are the same as in an intracapsular fracture. The great trochanter may be felt to be thicker and broader than on the sound side, as the result of comminution and impaction. The final diagnosis of the exact nature of the injury will always depend upon X-ray examination.

The treatment of fractures of the neck of the femur depends to some extent upon the age and general condition of the patient. If possible, the fracture should always be reduced into position and fixed until union has occurred, as in any other fracture. The method of reduction is simple. Extension on the limb and internal rotation of the lower fragment until the foot is vertical, together with wide abduction of the hip, will practically always bring the fragments into good position. The simplest method of accomplishing this is to place an extension upon both lower limbs, fixing each in a Thomas's knee splint. These splints are then suspended and weight extensions are fixed to their distal extremities and carried over a bar fixed to a four-post frame, the points of extension being separated as widely as is necessary to maintain the required degree of abduction, the bed being raised 10 or 12 inches at the foot. The weights upon the two splints can then be adjusted until the anterior superior spines are level—that upon the injured side being increased until the limb has reached its full length, and until the vertical measurement in Bryant's triangle is the same as upon the opposite side. When the position is apparently good, an X-ray photograph should be taken to determine whether it is really satisfactory. The object of the abduction is to force the fractured surfaces into contact with each other. In some cases this position of abduction can best be secured by the use of a net bed. It will be necessary to maintain this position for at least eight weeks.

In old people the recumbency essential to secure the best possible result may be dangerous, and great judgment will be required to decide whether such prolonged treatment is safe or not. A rather less satisfactory method is to extend upon the two Thomas's splints, raising the lower ends of the splints,

but only tilting the bed a very little and allowing the patient to be propped up with pillows or a bed-rest for some portion of the time. This method may be used in all except the very old. In the latter any form of recumbent treatment may be considered dangerous. It will then be necessary to abandon active treatment of the fracture, simply supporting the limb between sand-bags, with the knowledge, however, that the patient will probably never walk upon the limb again.

There is some question whether an impacted fracture of the neck of the femur should, or should not, be disimpacted. In young people there can be no doubt that, if the impaction means the persistence of an adduction and eversion deformity, the fracture should be disimpacted and the fragments put into proper position. It may not be necessary to do this by force; the use of the extension in an abducted position will generally reduce the deformity by more gradual means. In older people this gradual method of reduction may also be tried; if it fails, a forcible disimpaction should only be carried out if the patient is fairly robust and if the resulting deformity would be considerable if this were not done.

In children and adolescents treatment, either of a fracture or of a separation of the epiphysis, should be carried out by extension and abduction in exactly the same way. After eight or ten weeks, if union has occurred, a caliper splint should be worn, as in any other fracture of the femur, for a period of three to six months. Massage and gentle attempts to move the hip joint may be tried, but no force should be used, as the risk of re-fracture is considerable.

In extracapsular fracture a considerable limitation of movement of the joint or even ankylosis is probable. In intracapsular fracture a failure of union is frequent. In many cases this is due to the fact that the fracture has not been diagnosed early, or has not been treated in the abducted position. It does not, however, necessarily follow that failure of union is due to inefficient treatment. The head of the femur being completely isolated, is deficient in blood supply and in osteogenetic power, and this may itself be sufficient to give rise to non-union.

In an ununited fracture of the neck of the femur there is shortening of the limb with flexion and adduction, and perhaps eversion at the hip joint. A false joint is often present and, because of this, the limb is very unstable. The sciatic nerve may be involved where it passes over the posterior part of the fracture, so that sciatic pain, as well as pain in the hip itself, is common.

In many cases the patient is quite unable to walk upon the limb, or even to sit with comfort. In these cases the use of a caliper splint may enable the patient to regain walking power. If, however, the hip is much flexed and adducted, it will be difficult to fit such a splint, and a preliminary period of traction will be required. As a rule, the best result in such cases will be attained by excision of the head of the femur through a posterior incision. This allows the neck of the femur to engage against the pelvic wall, makes the fitting of a caliper splint much simpler, and does away with sciatic pain. Immediately after the excision the hip should be widely abducted and kept in this position for eight to ten weeks. It may then be fitted with a caliper splint to be worn for the next year.

The excised head of the femur will usually be found rarefied and covered with thin cartilage, which is much eroded, fibrous adhesions uniting the joint surfaces. These pathological changes indicate the futility of the various operations that have been performed for fixing an ununited intracapsular fracture by driving screws or pegs through the trochanter into the neck of the femur.

Plate 9.

Fracture through the lower third of the femur in a man aged 60, from a fall fourteen months previously. (A skiagram, taken from the side, kindly lent by Dr. D. Morgan from a case under the care of Sir Robert Jones.)

In ununited extracapsular fractures an operation for freshening the ends of the bone and fixation with a peg may be successful, but in them, if the bones are simply freshened and the limb fixed in the abducted position, union will probably occur, the peg not being necessary.

**Fracture of the shaft of the femur.**—Fractures of the shaft of the femur occur at all ages, more commonly in the young; they may be due to direct violence or to such indirect violence as a fall. The line of fissure may be transverse, oblique, or spiral. The fragments generally overlap, there being powerful longitudinally disposed muscles. The immediate shortening is therefore considerable.

In a fracture of the upper third of the shaft the upper fragment is abducted by the action of the gluteal muscles. It is also slightly flexed sometimes.

In the lower third of the shaft the lower fragment is usually angulated with the upper, the angle pointing backwards and the lower fragment being in a position as if the knee were flexed. This flexion deformity is commonly ascribed to the pull of the gastrocnemii. It does not appear that these muscles are likely to produce such a deformity by their unassisted action, however, for angulation of this sort is never seen after a transverse osteotomy of the lower end of the shaft. It is probable that the flexion deformity is first produced by the violence that fractures the bone, or by the weight of the body in falling after the fracture has occurred, and that it is only kept up by the action of the gastrocnemii. In the middle of the shaft the usual displacement is of the lower fragment backwards upon the upper, the lower fragment also being externally rotated.

In a complete fracture the diagnosis is simple, the limb being shortened with deformity, abnormal mobility, and often crepitus. Only if the fracture is incomplete will the diagnosis be obscured.

The reduction of the fragments into position must be carried out by a forcible extension upon the lower fragment. As there is a great tendency to recurrence of the displacement directly the extension is relaxed, complete preparations for fixation of the fracture should be made, the patient then anæsthetised, and the fracture reduced and fixed straight away. Only in cases of fracture of the upper and lower thirds, when the angulation already referred to is present and in occasional cases in which the fragments are interlocked, or muscle tissue interposed, will there be any difficulty in reducing the fragments completely by a simple forcible extension.

It must be remembered, however, that such an extension necessitates a counter-extension exerted upon the body in the opposite direction. When it is necessary to extend powerfully whilst the patient is under an anæsthetic, the best method is to fix clove hitches around the limb above the knee and above the ankle. A strong flannel bandage or a thick skein of wool may be used for this purpose. It is thus possible to get a pull both through limb and through these hitches. The counter-extension is best obtained by passing a roller towel under the perineum, so that an assistant can pull upwards through this.

In fractures of the upper third the abduction of the upper fragment must be allowed for by abducting the lower fragment. It was formerly taught that, in fractures immediately below the trochanters, the upper fragment is flexed by the action of the ilio-psoas. This does not appear to be true, or, at least, such flexion is only very small in amount. It must be remembered that the gluteal muscles are also attached to the upper fragment and serve to maintain extension.

In fractures of the lower third, when the lower fragment is displaced

backwards, it can be replaced by flexing the knee over a sandbag whilst the pull upon the ankle is maintained.

In fractures of the middle of the shaft a simple extension is usually sufficient to secure a good alignment of the fragments.

Actual manipulation while the extension is maintained is the only other manœuvre required. Most often it will be found necessary to lift the lower fragment forwards and to rotate it inwards. If it has been possible to X-ray the fracture before attempting reduction the plates will give considerable assistance in guiding any manipulation that may be necessary to unlock the fragments from each other. In cases in which there is a difficulty due to interlocking the general rule of starting by angulating the bone so as to increase the deformity may be found to assist; but this method must be used with care, because in the thigh there is a risk of sharp fragments damaging important structures round the bone.

In order to ascertain whether a good reposition of the fragments has been secured, the alignment of the bone should first be noted and the limb then measured. In taking the alignment of the bone the anterior superior iliac spine, the inner border of the patella, and the internal malleolus should be brought into a straight line, so that the patella is made to look forwards and a little outwards, the foot being externally rotated about 15 degrees from the vertical. It should then be ascertained that the great trochanter lies at the same distance behind the level of the anterior superior spine as is that of the other side with the limb in the same position.

It must be remembered that the shaft of the femur has a forward convexity; unless this is allowed for, an angulation of the fragments backwards will often be discovered in a fracture that is thought to have united satisfactorily. It is for this reason that it is often necessary in manipulating the fragments to lift the site of the fracture forwards. The limb should be measured whilst the patient is still anæsthetised and the extension maintained. If possible, a pull should be kept up until the limb is actually longer by half an inch than that on the opposite side. In a recent fracture in a healthy person shortening at the time of the setting of the fracture should never be permitted.

Full length and good alignment being secured, fixation upon the splint is the next step. In the case of the femur continuous extension for a period of weeks is nearly always essential, and, as already mentioned, such extension necessitates a counter-pressure or extension in the opposite direction. There are two methods by which such a counter-extension can be secured. The pull may be exerted by attaching the extension straps to a splint, the upper end of which presses against the pelvis at the only point at which such pressure can be borne, that is, against the tuberosity of the ischium; or, the extension being attached either to a fixed apparatus or to a cord which passes over a pulley, the patient's bed may be tilted with the head downwards, so that the body weight constitutes the counter-extension.

The first of these methods is undoubtedly the more efficient, because the splint, pressing against the tuberosity of the ischium, fixes the upper fragment in a way that can only otherwise be accomplished by fixation of the whole pelvis, lumbar spines, and thorax with the splint or with plaster of Paris. The pressure often necessary, however, may be extremely irksome, or may produce a sore, so that the use of the body weight as counter-extension is preferred by many surgeons. A compromise between the two methods is the best and the most comfortable.

The Thomas's splint has replaced all other splints in the treatment of fractures of the femur. It is applicable to fractures at all levels, simple or

compound. As the ring of the splint secures pressure against the tuberosity of the ischium, the direct method of counter-pressure may be used. In order to relieve this pressure the splint may be slung to a frame and a weight extension attached to its lower end. This weight extension should not be allowed to pull the ring of the splint quite away from the tuberosity of the ischium, but should merely relieve the pressure at this point.

In fractures of the upper third the necessary abduction is best secured by the use of Thomas's splints on both lower limbs, the splints being slung upon a four-post frame and abducted to the extent necessary to secure the correct angle, the weight upon each splint being adjusted until the anterior superior spines of the ilium are at the same level.

The anterior convexity of the femur is secured by adjusting the transverse slings upon which the limb rests to the correct degree of tension. Complete fixation of the fragments is carried out by placing small metal splints behind and, if necessary, on either side of the fractured region, and fixing these with encircling bands of webbing.

Occasionally it is found desirable to exert considerable pressure against one side of the fracture; the simplest method is to use along this side a metal splint, which is firmly tied to the opposite bar of the Thomas's splint.

Excellent results are also obtained in fractures of the upper third by the use of a Sinclair's net bed.

In a fracture of the lower third with angulation the Thomas's splint should be bent at the knee to the extent necessary to overcome the angulation. The use of the splint thus bent is often made a routine. If a caliper extension is used, bending of the splint is practically always necessary. Further details of the use of a Thomas's splint for fractures of the thigh are described under Methods of Fixation in the Lower Limb (see p. 540).

When a fracture of the femur has been reduced and fixed upon the splint it should invariably be X-rayed, in order to ascertain that the position is as perfect as possible. Two X-rays are desirable, taken in the antero-posterior and lateral positions. In the upper third of the bone the lateral view cannot be obtained, and a stereoscopic photograph should then be used instead. These X-rays must be taken upon the splint without disturbance, or with only the removal of any small encircling metal splints. The limb should be measured immediately after it has been fixed, and measurements repeated at first daily, later at intervals of three or four days. The extension must be constantly watched and adjusted, being replaced with as little disturbance as possible if any slipping occurs.

Fixation of the thigh should be kept up in a simple case for at least ten weeks, the extension being maintained throughout. In a child, at the end of this period, provided that the bone has united with perfect alignment, it should be strong enough to bear weight. In an adult an ambulatory splint should invariably be worn for a period of three months. In certain fractures, particularly those which have been compound or in which a perfect alignment has not been secured, it may be necessary to wear such a splint for six months, or even longer. A Thomas's caliper splint is the form of splint ordinarily used for this purpose.

The method of treatment so far described is universally adaptable both for simple and for compound fractures. In children, however, other methods may sometimes be adopted with advantage. In children under one year of age the natural position of the hip may be taken to be that of right-angled flexion. For this reason it is advantageous to extend the limb almost directly upwards. The old method was the use of simple extension to a gallows splint.

At the present day a Thomas's splint will be used, slung, however, much higher than in the case of an adult.

In older children fixation of the limb in plaster of Paris whilst the patient is anæsthetised is the simplest and most satisfactory method. The fracture must first be reduced by powerful extension and counter-extension, full length being obtained and the fragments manipulated into good alignment; a plaster

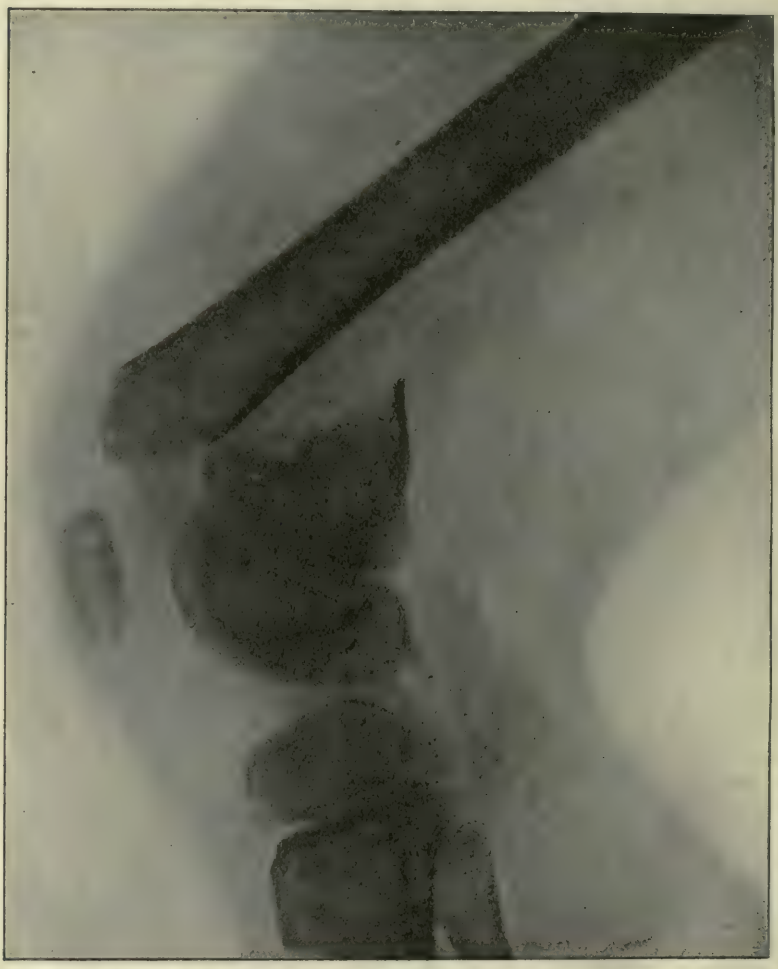


FIG. 241.—Fracture of the lower third of the femur in a young patient, with displacement of the upper fragment forwards. (A lateral skiagram from a case under the care of Sir Robert Jones, kindly lent by Dr. D. Morgan.)

of Paris case should then be fixed, extending from the toes up to the axilla: the top of the thigh should be well padded at the back, and the plaster strengthened and moulded against the tuberosity of the ischium. In fractures of the upper third of the bone, when it is found necessary to maintain abduction, the plaster of Paris should include the top of the opposite thigh.

After a fracture of the femur has united there is usually considerable stiffness of the knee joint and much wasting of the thigh muscles. Many

endeavours have been made to obviate this by early movement of the knee joint. It must be said, however, that such early movements can only be carried out without risk of displacement of the fragments if a caliper extension is used.

The question then arises whether it is justifiable to cut down upon the condyles of the femur and insert the prongs of the caliper in every case of fractured femur, in order to obviate after-stiffness of the knee. In simple fractures of the bone the stiffness is overcome with comparative ease, and, inasmuch as the use of the calipers does involve a slight risk of septic infection in the neighbourhood of the knee joint, it would appear better to allow the knee to become stiff, trusting to physical methods for overcoming this at a subsequent stage.

Much can be done to keep the thigh muscles in condition by treating them daily with a faradic coil by Bristow's method. The quadriceps muscle is that which is most likely to be affected. It should be stimulated at two points: (1) the common quadriceps point, which causes a contraction of the rectus, vastus externus, and crureus, and (2) a point over the vastus internus for this special part of the muscle. This treatment can easily be carried out whilst the limb is fixed upon a Thomas's splint.

FIG. 242.—Ununited fracture of the patella. (St. Bartholomew's Hospital Museum.)

Compound fractures of the femur can be treated upon the Thomas's splint in exactly the same way as the simple fractures. The chief difficulty—that of the dressings necessary—is easily overcome with this splint without the disturbance of position.

In certain cases of fracture high up, with wounds in the neighbourhood of the ring of the splint, it may be preferable to use Sinclair's net bed as a method of support.

Stiffness of the knee is an exceedingly troublesome complication of compound fractures. Such stiffness is due to a number of causes. A septic inflammation around the joint leading to fibrosis, infection, and scarring of the quadriceps muscle, and adhesion of this muscle to the bone, is the most important extra-articular cause. But an exploration of knees stiff as the result of compound fractures of the femur has shown that an actual quiet infection of the joint is a common occurrence. The joint surfaces are found eroded, the cartilage and bone pitted, the synovial membrane and even the bone surfaces being adherent. When such intra-articular complications have occurred they may be demonstrable in an X-ray photograph.

The use of a caliper extension, allowing early movement of the knee, may do much to obviate stiffness of the joint in infected compound fractures by lessening peri-articular adhesions and adhesions of muscles. When intra-articular changes occur, even this method cannot be expected to leave a mobile joint.

The routine treatment of fractures of the shaft of the femur by operation has been much advocated, largely because poor results have been obtained by other methods. It has, however, been amply demonstrated that in most

simple fractures of the femur a practically perfect result can be secured by efficient methods of splinting without operation. Only in cases in which a good position cannot be secured or maintained, and in cases of non-union and mal-union, is operative treatment advisable. When it is necessary, a wide exposure of the bone by an incision along the outer side should be made, the fragments being levered into place by angulation against each other. It may then be found possible to secure the position by simple splinting, and this is preferable to the use of a metal plate; the latter is practically the only method that is sufficiently strong to hold a femur which cannot be held by an extension and an external splint. Such a plate should be reserved for very special cases, a long plate with at least five screws in each fragment being used. Apart from the general objections to the use of plates, there is a special objection in the case of the femur, namely, that there is apt to be a very persistent after-stiffness of the knee, due to infiltration of the quadriceps muscle with blood and to subsequent fibrosis.

FIG. 243.—Separation of the lower epiphysis of the femur; the diaphysis is displaced backwards and the condyles rotated into the position of flexion. (St. Bartholomew's Hospital Museum.)

The ambulatory treatment of fracture of the femur has already been sufficiently described.

**Fractures of the lower end of the femur.**—Fractures of the lower end of the femur may be grouped under supra-condylar fractures, T-shaped fractures, and separation of the lower epiphysis. Other irregular fractures extending into the joint also occur.

In supra-condylar fractures and in T-shaped fractures the lower fragment, or fragments, are usually displaced backwards, the lower end of the upper fragment projecting forwards into the region of the patella. This fragment may penetrate the joint and may come through the skin. The diagnosis in these injuries is generally obvious. The T-shaped fractures differ from the transverse in that the condyles are widened and are mobile on each other.

These fractures are best treated upon a Thomas's splint with extension, the knee being flexed as much as is found necessary to secure a proper position. Early movement of the knee is impossible without displacement of the fragments, and should not be attempted.

Separation of the lower epiphysis is rare. It results from indirect violence, such as a violent twist, the epiphysis being usually carried forwards and the lower end of the shaft projecting into the popliteal space. This injury may be suspected when a severe accident to the knee in a young person leaves a deformity in which the knee hyper-extends and there is a hollow anteriorly above the patella. There may be little or no movement at the site of the separation.

The diagnosis must be completed by an X-ray examination and treatment carried out on the same lines as in a fracture of the lower end of the bone.

In irregular fractures of the condyles treatment by extension, manipulation, and fixation upon a Thomas's splint with lateral pressure is indicated.

**Fractures of the patella.**—Fractures of the patella are common in adults. There are two main varieties, the bone may be separated by a transverse

Plate 10.

Skiagram of a fractured patella in which the fragments have been wired. (Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

fissure into an upper and a lower fragment, or it may be split into a number of pieces; the former is the ordinary transverse fracture, the latter—or starred fracture—is less common, and is due to a direct injury to the bone. Very occasionally the bone may be split vertically or a piece chipped off from one border by a direct injury. In a stellate fracture and in other fractures due to direct violence the displacement of the fragments from each other is usually slight, and the treatment is simple. If seen early, effusion into the joint should be limited by the use of elastic pressure over a thick pad of cotton wool, the limb being rested upon a back splint for a month, and then treated by massage and exercise to restore mobility.

The more common transverse fracture is due to an indirect injury. The patient usually slips and falls forward, but the patella breaks before the knee strikes the ground. Whilst the joint is flexed to about a right angle, a violent contraction of the quadriceps muscle, made by the patient to save himself, cracks the patella across the condyles of the femur, just as a piece of wood may be cracked across a wedge. The fragments become separated to a greater or less extent, according as the lateral expansions of the quadriceps tendon into the capsule of the knee joint are more or less torn. Separation may be hardly noticeable, or may be as much as 4 inches. The bone may be broken into practically equal upper and lower halves, or the upper fragment may be very small; rarely the lower fragment may be small, and in occasional cases the injury becomes almost a separation of the patellar ligament from the lower margin of the bone, or even a rupture of the ligament itself.

This fracture opens the synovial cavity of the knee joint, which soon becomes filled with blood. In spite of the swelling, diagnosis is usually simple, because the gap between the fragments can be distinctly felt. This gap is widened by flexing the knee. Active extension of the knee is impossible, except in those cases in which the lateral expansions of the tendon are intact and the separation very slight.

In transverse fracture of the patella bony union does not occur unless an operation has been performed, because the pull of the quadriceps muscle makes it almost impossible to secure apposition of the bone surfaces by any external splint, but close fibrous union between the fragments may lead to a functional result which is very little short of perfect.

It is customary to treat all fractures of the patella in healthy adults by operation, but the possibility of securing a sound limb by other methods should always be borne in mind, particularly in cases in which, for reasons of constitution or age, an operation is not desirable. The non-operative method of treatment consists in the use of a back splint with a footpiece, the thigh section of the splint reaching as high as is convenient, and the whole splint being raised upon a bed to an angle of 45 degrees in order to flex the hip, and so diminish the strain on the rectus femoris. Pads are then cut to the shape of the upper and lower borders of the patella and strapped with figure of eight turns of strapping, so as to pull the upper fragment down and the lower fragment up. This position should be maintained for four weeks, and a light back splint then fixed to the knee and similar pads and strapping applied. At the end of two months flexion of the knee may be allowed. If a gap of less than an inch remains between the fragments, a fairly good functional result should be obtained, although the knee may be weak when tested on a hill or on stairs. As it is necessary to keep the quadriceps muscle out of action throughout the period of treatment, a considerable amount of massage, electrical treatment, and exercising will be required in order to restore good use.

In most cases fracture of the patella will be treated by operation. A few days' interval between the injury and the operation does no harm, and this period may be utilised to diminish the effusion by the use of a compression bandage and gentle massage.

The bone is explored either by a U-shaped incision, a flap being turned upwards, or by a curved incision to one side of the patella: the ends of the bone are cleaned and brought into contact accurately, being then sutured with wire or with an absorbable suture. When there is little tension it may be sufficient to suture the lateral expansions of the quadriceps securely together with catgut. When there is much tension the bone itself should be fixed—either silver wire or strong kangaroo tendon being used. In passing the suture care must be taken that, when it has tightened, the fragments do not become angulated upon each other. The most satisfactory method is first to channel across the upper part of the patella under the tendinous part of the quadriceps, to drill two holes from this region vertically through to the fractured surface of the upper fragment, and to continue these holes through the lower fragment so that they emerge on either side of the patellar ligament. The suture is then passed from above through one side of the upper and lower fragments, transversely through the patellar tendon and upwards through the other sides of the lower and upper fragments. The upper fragment is then pulled down by two pairs of tissue forceps applied to the tendinous expansion on either side of it, and the suture tightened. By this means tilting of the fragments is avoided and the suture is entirely buried. When a wire suture is passed in such a way that the twisted end lies over the bone it not uncommonly works through the skin, and has to be removed at a later date.

The object of an open operation on a fractured patella is to secure bony union. This will only take place if the fractured surfaces are brought into accurate contact. If such contact has been obtained, movement of the knee may be commenced at the end of a fortnight, no force, however, being used. If good contact of the bone has not been obtained fibrous union must be expected, and the after-treatment should be the same as that of a fracture which has been treated without operation.

Many other mechanical methods for the treatment of fractures of the patella have been devised; these, however, have been rendered obsolete by the safety of an open operation.

**Fractures of the upper end of the tibia and fibula.**—Fractures of the upper end of the tibia and fibula are uncommon and usually of an irregular nature, due to direct violence or to severe indirect violence, such as a fall from a height. Most commonly there is an oblique fissure, extending into the joint and separating a portion of the head of the tibia. There may be two such fractures, the shaft of the bone being driven up into the two fragments into which the head is separated.

The diagnosis of these injuries must depend upon X-ray examination, although widening of the head of the tibia and tenderness on pressure along the line of the fissure may give rise to the suspicion that such a fracture exists. A displacement of part of the head of the tibia produces a genu valgum or genu varum deformity, which it is important to correct.

In the rare transverse fractures of the tibia immediately below the head an angulation of the lower fragment may produce either an apparent hyper-extension of the knee or an apparent deficiency of full extension. These fractures must be reduced by powerful traction upon the leg combined with lateral pressure, an X-ray examination being made to determine that the

Plate 11.

Oblique fracture of the tibia. (Skiagram taken by Dr. Hugh Walsham.)

alignment is sufficiently good. A perfect result is not to be hoped for, but care should be taken that no angulation is allowed to remain, and every effort should be made to get the margins of the fracture in the articular surface into accurate apposition, for a displacement at this point will leave considerable permanent disability.

As continued extension will probably be required, a Thomas's splint, combined with lateral pressure around the knee, forms the best method of fixation.

Fracture of the head of the fibula is very rare; the most important form is that in which a part of the head of the bone, carrying with it the attachments of the external lateral ligament of the knee-joint and the biceps tendon, is separated. Unless such a fracture is recognised and treated by immobilisation of the knee, a permanent lateral mobility of the joint will result.

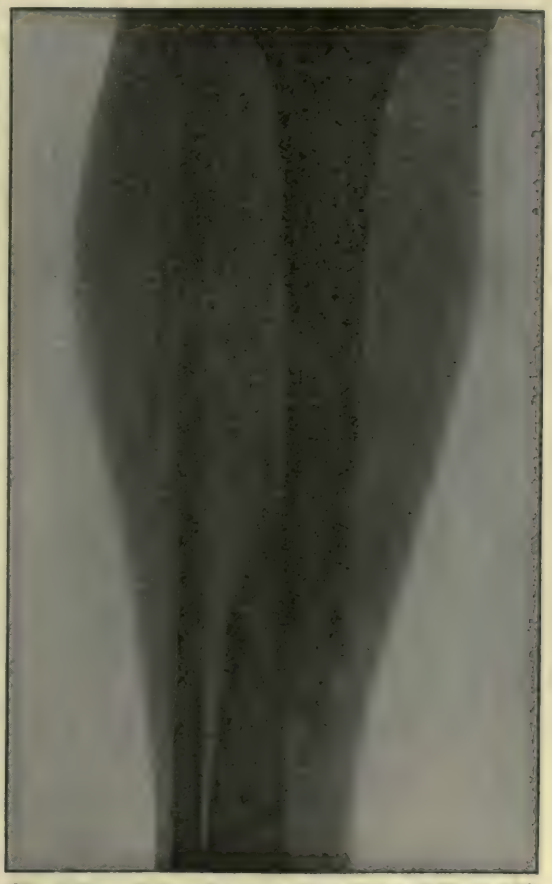


FIG. 243A.—Oblique fracture of the tibia and fibula with displacement of the fragments. (From a skiagram taken by Dr. Hugh Walsham.)

**Fractures of the shaft of the tibia and fibula.**—One or both bones may be broken, either by direct or by indirect violence. An oblique or spiral fracture of the tibia is much more common than a transverse fissure. In fractures by direct violence the two bones may be fractured at the same level. If the violence is indirect, the level of the fractures may be different.

The displacement of the fragments depends upon the fracturing force or upon some other external force occurring immediately after the fracture. There is usually some degree of overlapping and angulation and often a rotation of the lower fragment upon the upper. As a rule, the presence of deformity, abnormal mobility, and crepitus render the diagnosis easy, but in simple fissures without displacement these signs, except for localised pain, may fail, and in fracture of the fibula alone the presence of local tenderness will nearly always be the only sign. In the latter, pain induced by pressing the shaft of the bone towards the tibia is an important sign of fracture.

Fracture blisters, although they may occur after an injury of any region, are particularly common in the leg. They usually appear from twenty-four

to forty-eight hours after the injury. Their exact cause is not known, but it is probable that they result from obstruction to the circulation by tension from extravasated blood. They can practically always be prevented if the fracture is seen within the first few hours, and is then treated by wrapping the limb in a thick uniform layer of cotton wool over which a flannel or domette bandage is applied with uniform firm pressure from the toes up to a point above the knee, the bandage extending not quite so far as the padding of cotton wool.

Reduction of the fragments of a fracture of the tibia and fibula into position may be simple or extremely difficult. Traction upon the foot and manipulation are the methods to be relied upon. The difficulty is generally that the fracture is oblique or spiral, and that the fragments have become in some way interlocked. A knowledge of the exact shape of the fragments, determined by means of an X-ray, will assist very greatly in the reduction.

FIG. 244.—Compound fracture of the tibia united with much shortening and with internal rotation of the lower fragment. There was a chronic ulcer over the tibia. Treated by (1) excision of the ulcer and suture, and (2) subcutaneous osteotomy below the area of the fracture.

In determining whether full correction has been obtained the limb should be compared with its fellow and inspected from the front and either side, a measurement being taken to see that no shortening remains.

Apart from lateral angulation, which is always avoidable, the most frequent errors in reduction and fixation are due to allowing an angulation backwards at the site of the fracture, leaving the front of the tibia concave instead of convex, and a rotation of the lower fragment inwards upon the upper, due to a failure to fix the knee adequately in the splint. Either of these may give rise to serious disability and an ugly deformity.

In those fractures in which the deformity has been slight and easily reduced the best method of fixation is by enclosure of the limb from the toes to well above the knee in plaster of Paris, the plaster being applied with uniform pressure over the cotton-wool padding already mentioned. The foot should be at a right angle, and the plaster should be well moulded around it and around the knee, so that rotation inside the case cannot occur. When the swelling subsides, the plaster soon becomes loose, so that it is as well to replace it at the end of a fortnight, readjusting the position if necessary. Late displacement or angulation of the fragments may occur, and for this reason fixation for five or six weeks is necessary, early movement of the knee and ankle being out of the question. If stiffness of the ankle-joint remains, it will be easier to secure a return of plantar flexion than of dorsi-flexion. For this reason it is important to make sure that the foot is originally set at a right angle.

In many fractures of the tibia the maintenance of the corrected position is difficult and necessitates a continuous extension. Such a fracture is best treated upon a Thomas's knee splint, the extension being obtained either by strapping applied over the lower fragment or by means of a Sinclair's footpiece.

In using a Thomas's splint for this fracture it is necessary to take special precautions against angulation backwards and rotation inwards of the lower fragment. Backward angulation is prevented by a proper adjustment of the slings upon which the calf rests, and inspection of the leg from the side as a routine will be sufficient to guard against it. Rotation of the lower fragment results from an imperfect fixation of the knee; the foot is held vertical, but the position of the knee ignored. There is a tendency for the thigh, knee, and upper fragment of the tibia to rotate outwards, so that inspection may show that the patella, instead of pointing forwards, is pointing towards the outside bar of the splint. If the fracture is allowed to unite in

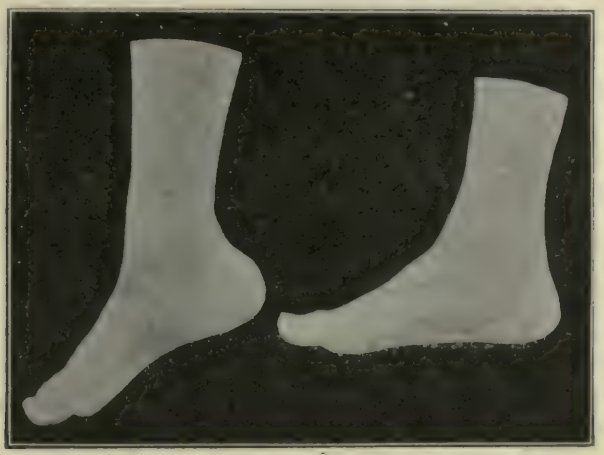


FIG. 245.—Pott's fracture mal-united, with severe valgus deformity and backward displacement of the foot. Corrected by reconstruction of the fracture. Plaster casts of the foot before and after treatment.

such a position a most unsightly in-turning of the toe results. The best method of guarding against this deformity is to bend the Thomas's splint opposite the knee joint, to enclose the knee in plaster of Paris, which is moulded around the patella and condyles, and to include the side bars of the splint in this plaster. The position of the knee is thus fixed, and the foot can be adjusted to correspond. Fixation upon the Thomas's splint should be continued for six weeks, or until it can be replaced by plaster of Paris. Compound fractures are best treated upon a Thomas's splint.

After the removal of the splint or plaster of Paris, massage and mobilisation of the knee and ankle will be required until full movement and muscle power return. In a fracture treated upon a Thomas's splint it may be possible to keep up small movements of the ankle by using faradic stimulation of the muscles, more particularly of the anterior tibial and peroneal groups.

A simple fracture of the shaft of the fibula requires only fixation in plaster or upon a splint for a period of four weeks.

If a replacement of the fragments of a fractured tibia in proper position has been found impossible an operation should be performed. The objects

will practically always be to disengage the fragments from each other and replace them in position. Fixation by plates or other internal means is scarcely ever required.

Mal-union of a fracture of the tibia should be corrected by osteotomy whenever any functional disability results. A reconstruction of the fracture is unlikely to be required, as the necessary adjustment can practically always be made by a simple subcutaneous osteotomy or by the removal of the wedge.

Non-union of fractures of the shaft of the tibia is rare. Occasionally a fracture in the lower third in a child fails to unite. In such cases the lower fragment becomes atrophic, and even the use of a bone graft may fail to secure union. A grafting operation should, however, be tried, as the only alternative is the use of a permanent appliance or amputation at the site of the fracture. Apart from these rare cases, non-union occurs only in compound fractures in which there has been much destruction of the bone. In some of these an intact fibula prevents the fragments of the tibia coming into close apposition with each other. An oblique osteotomy of the fibula, the ends being allowed to slide over each other, may then result in union. In other cases the use of a bone graft is indicated.

**Pott's fracture.**—Pott's fracture is a fracture-dislocation of the ankle region produced by forced abduction or external rotation of the foot. In the typical fracture the internal malleolus of the tibia is separated, the shaft of the fibula is fractured either transversely just above the lower tibio-fibular articulation, or spirally in a line extending up the shaft, and the foot is displaced outwards and backwards. In some cases the internal lateral ligament is ruptured instead of the malleolus being separated. In others the fracture through the tibia includes a fissure extending upwards from the articular surface to a point on the back of the shaft. In the latter group the fragment of tibia thus separated is carried backwards with the foot.

This fracture is produced by comparatively slight violence. A twisting of the foot on to its inner side or a force applied to the outer side of the leg may be sufficient. The fractures thus produced are abduction fractures; the fibula is usually broken close to its lower end and the backward displacement of the foot is not great.

In other cases a forcible external rotation is the cause of the fracture, the foot perhaps being caught in something and violently twisted outwards. The fracture in the fibula then tends to extend up the shaft and the backward displacement of the foot is greater.

The external appearance of Pott's fracture is very characteristic. There is often much swelling, both of the soft parts and of the ankle joint itself. The foot is everted and appears to be pushed bodily outwards, the internal ankle being very prominent and a hollow appearing above the external malleolus; the heel, being displaced backwards, appears longer than on the sound side, the anterior part of the foot being correspondingly shortened.

If the backward displacement is severe the lower end of the tibia may be actually seen or felt as a prominence in front of the ankle-joint. There is a corresponding concavity posteriorly over the tendo Achillis.

This is the deformity of a fracture with complete displacement, but fractures with little or no displacement are common. In a Pott's fracture in which there is no displacement or in which the displacement has been reduced, there remain for a considerable period three points which are tender to pressure in a characteristic manner. These points are the internal malleolus, the anterior edge of the lower extremity of the tibia, and the fibula close

above the external malleolus. An injury of the ankle-joint in which these three points are tender should be treated as fracture until an X-ray photograph has been obtained.

Several other fractures of the ankle region occur. In some cases a forcible

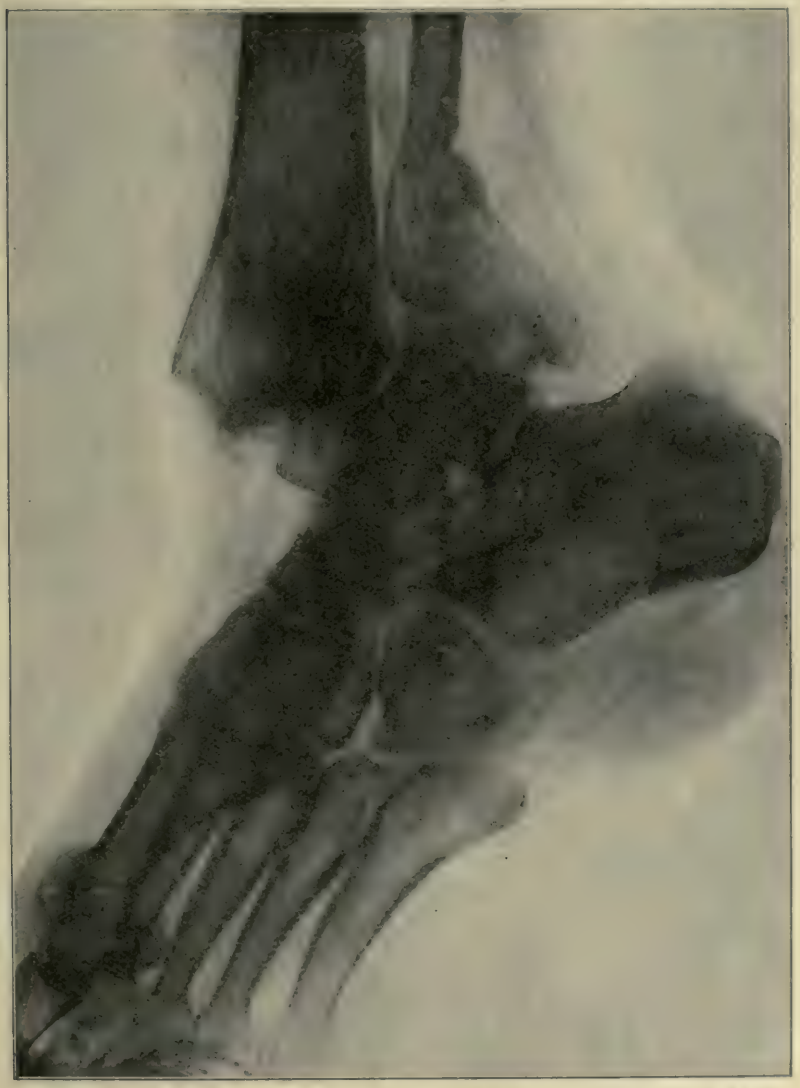


FIG. 246.—Pott's fracture, with great displacement backwards. (Skiagram taken by Dr. Hugh Walsham.)

inversion of the foot produces a fracture of the internal malleolus and of the fibula, the foot, however, being adducted and inverted. These fractures are sometimes called "reversed Pott's fractures."

In Dupuytren's fracture the injury resembles that of Pott's fracture, but, in addition, the inferior tibio-fibular ligament is ruptured, the tibia and fibula are separated from each other, the astragalus tilting up, so that the outer edge

of its articular surface lies between them. This fracture differs from Pott's fracture chiefly in that the leg is widened just above the ankle-joint.

Complete reduction of a Pott's fracture is all-important. If the bones are replaced fully, the result will be at least moderately good. If much displacement is left, a permanent lameness, which may be severe, is certain. The patient should always be fully anæsthetised and an effort made to produce an apparent over-correction of the deformity. In case of difficulty the fragments should first be freed from each other by forcing the foot still further backwards and outwards, and so increasing the deformity. Then, when the fragments are quite loose, the foot can be pulled upon and inverted, and the heel lifted forwards until correction is complete. As a final step, an endeavour should be made to bring the foot to a right angle with the leg. If this method is adopted at an early stage it is practically never necessary to perform an open operation.

The only satisfactory method of fixation of Pott's fracture is in plaster of Paris, the foot being held inverted and at a right angle. The first plaster case should be applied over a cotton-wool padding. It need not extend above the knee-joint. This plaster should be removed as soon as it becomes loose and replaced by a case which is cut into two lateral halves. At the end of a fortnight this case may be removed daily for massage and gentle active movements. Forced passive movement must not be used until a month from the time of the fracture, and great care must be exerted in forcing abduction of the foot, this movement being left until the last.

It is a matter of extreme difficulty to fix a Pott's fracture satisfactorily upon any of the splints commonly used for this purpose, whereas fixation in a plaster case whilst the patient is under an anæsthetic is quite simple.

The other fractures named should be treated in the same way, that is, by correction under an anæsthetic and fixation in plaster.

A compound fracture, if the wounds are small enough, is best treated in plaster of Paris with a window to facilitate dressings. In cases in which extensive surface injury has occurred a Thomas's splint with extension by means of a Sinclair's footpiece is the most likely to give good results.

Injury of the lower epiphysis of the tibia is an occasional result of a lateral strain of the ankle in a young person. It would appear that the usual injury is due to forcible inversion of the foot and that this produces a vertical fissure through the epiphyseal plate at its thinnest part, this fissure being then opened out slightly and the inner half of the epiphysis, with the internal malleolus, separated. Such an injury is usually diagnosed as a simple sprain, as the displacement is very slight and the fissure not obvious, even in an X-ray photograph. A year or two later, however, interference with growth at the inner part of the epiphyseal line causes a varus deformity and demonstrates the true nature of the original accident.

**Fractures of the tarsal bones.**—Fracture of the astragalus most often results from a fall from a height on to the heel. The bone may be separated into two fragments by a fracture through the neck or it may be fissured or crushed.

In injuries due to a fall a dislocation of the posterior fragment is not unusual. Injuries of the astragalus—fractures, fracture dislocations, dislocations, and sub-astragaloid dislocations—are all of comparatively frequent occurrence in flying accidents, the mechanism being a sudden crushing pressure exerted upon the bone between the os calcis and the tibia in a fall in which the feet are forced downwards against the rudder bar.

In simple fracture of the astragalus without dislocation the diagnosis must

be made by localised pain and widening of the bone below and in front of the malleoli, the actual nature of the injury being determined by X-ray examination.

When the injury is accompanied by dislocation a lateral deformity of the foot, usually of the nature of a severe valgus deformity, co-exists, or the dislocated portion of the bone may be felt in some abnormal situation.

In fractures without dislocation the foot should be fixed at a right angle in plaster of Paris for three weeks, gentle massage and movements then being used. If it is impossible to replace the fragments accurately in position, an effort should be made in the first place to fix the foot so that it is neither inverted nor everted, the heel being in proper alignment for normal walking. Persistent pain and swelling are not uncommon after a fracture of the astragalus, and a perfect result is not to be expected.

In cases in which there is dislocation of the posterior fragment an excision of the whole or greater part of the bone is indicated.

**Fracture of the os calcis.**—The body of the os calcis may be fractured by a fall upon the feet, the bone being fissured or crushed. The fractures are irregular, without any fixed type of displacement. The bone is usually widened, and this sign has to be relied upon as indicating the advisability of an X-ray examination.

In rare cases that portion of the os calcis to which the tendo Achillis is attached may be separated by the forcible action of this muscle.

In fissured or crushed fractures fixation of the foot and ankle in plaster of Paris for three weeks, followed by massage, is the proper treatment.

In fractures involving the attachment of the tendo Achillis, if the separation is complete, operative treatment to fix the fragment in place is the best.

**Fracture of the scaphoid.**—An injury of the scaphoid due to a fall or trip is not uncommon. An X-ray photograph shows the bone in two portions, the tubercle being apparently fractured. In all such cases the sound foot should also be examined with X-rays, as a separate bone, representing the tubercle of the scaphoid (os tibiale sesamoideum), is not very uncommon. Probably in most cases an alleged fracture of the tubercle of the scaphoid will be found to be due to the presence of this additional bone, which has been loosened and made painful by the injury.

If in such a case fixation of the foot for three weeks does not relieve the pain the separated fragment of bone is better removed.

Other fractures of the tarsal bones are irregular in nature, and due usually to direct violence. They should be treated by fixation in plaster of Paris after the foot has been carefully adjusted to as normal a shape as possible.

**Fractures of the metatarsal bones** may be caused by direct violence, such as the passage of a wheel over the anterior part of the foot. In addition, however, one of the middle metatarsals may be fractured without any history of violence, a fissure appearing in the bone after the patient has walked for some distance (marching fracture). The latter type of fracture gives rise to a tender swelling upon the metatarsal bone in its anterior third, an X-ray showing a fissure across the bone with, perhaps, some callus around.

Fractures of the metatarsal bones should be treated by immobilisation for three weeks after as complete reduction into position as possible. The marching fracture will remain chronically painful until the foot has been rested for a period of two to three weeks.

Fractures of the phalanges require no special consideration.

## Section XII.

### DISLOCATIONS.

**Definition.**—A dislocation is an abnormal displacement from each other of the articular portions of the bones which form a joint. If the articular surfaces are separated completely from each other, the dislocation is complete. In certain joints the displacement may be partial. For example, in the temporo-maxillary joint the condyle of the jaw may be displaced forwards on to the eminentia articularis or may pass in front of this. In the sterno-clavicular joint, partial displacements are common. In certain other joints partial displacements result from pathological conditions in which there is a laxity of the ligaments. These partial dislocations are classed as "sub-luxations."

Dislocations may be simple or compound (if there is a wound extending down to the joint), or they may be complicated by other injuries. They are usually named according to the joint involved and to the direction of displacement of the distal bone. Thus a dislocation of the elbow backwards means that the radius and ulna are displaced backwards on the humerus. A sub-coracoid dislocation of the shoulder means that the head of the humerus is displaced forwards so that it lies below the coracoid process. In certain cases an entire bone is displaced, there being really dislocations of the joints on either side of it. These are described as dislocations of the bone. For example, the astragalus may be dislocated forwards, and the semilunar bone of the carpus may be dislocated on to the palmar surface.

Dislocations of the shoulder are four times as common as those of the elbow, the latter being more frequent than those of any other joint. Dislocations of the jaw, of the joints of the fingers, and of the clavicle come next in frequency. Traumatic dislocations of the hip are rare.

**Causation.**—The anatomy of the joints, particularly the strength given to them by the arrangement of the articular surfaces, of the ligaments and of the muscles around, is the chief factor in determining the ease with which an individual joint can be dislocated. The shoulder-joint has a lax capsule, articular surfaces which do not in any way interlock, and ligaments which are but weak. It depends upon muscles for its support, and because of its very great range of movement leverage may easily be exerted which will overcome the muscles on one side of the joint and lever the head out of its capsule. The violence which produces a dislocation is practically always a leverage.

The shoulder is dislocated by an upward and backward strain applied to the humerus. The neck of the humerus meets the base of the acromion, the head being levered forwards and downwards. At this situation there is a comparatively weak part of the joint, supported only by the subscapularis muscle, and the head of the bone may easily tear the capsule and escape. This is much more likely to occur if the muscles are at the moment off their guard.

Only very rarely does dislocation result from force exerted by the muscles themselves, probably because the co-ordination of the muscles brings into play a contraction of such muscles as would prevent the dislocation. In the shoulder-joint, however, dislocations by muscular violence may occur during

epileptic fits and, when recurrent dislocations of this joint take place, muscular violence is not an uncommon cause. In such recurrent dislocations there may be a permanent opening in the capsule or an overstretching of the capsule in a particular direction. Recurrent dislocations occur also in the jaw and in dislocation of the patella. In the latter an overstretching of the inner part of the quadriceps muscle is an important factor.

**Pathological anatomy.**—As a rule, in a dislocation there is a rupture of the capsule of the joint, not necessarily, however, on the side upon which the displaced bone is found upon examination. In the so-called regular dislocations of the hip the head of the femur probably always escapes from the joint upon the lower and inner side, the tear in the capsule being situated at this point. Most often, however, the limb rotates after the dislocation has occurred, so that the head of the femur lies upon the dorsum ilii. The original displacement is called the primary displacement, that which occurs subsequently being secondary. A possible exception to the rule that a rupture of the capsule occurs may be found in dislocation of the temporo-maxillary joint. Rupture of muscles may occur, or a muscle may tear off the portion of bone to which it is attached; thus, in dislocation of the ulna backwards, the coronoid process may be separated, carrying with it the attachment of brachialis anticus.

An important point in settling the fate of a dislocation is the presence or absence of injury of the more powerful ligaments, such as the orbicular ligament of the radius, the Y-shaped ligament of the hip and the crucial ligaments of the knee. When such ligaments have been torn, maintenance of reduction of the dislocation may be difficult and a permanently laxed joint may result.

Other complications of dislocations are fracture of the articular surfaces of the bone, fracture of the dislocated bone in the neighbourhood of the joint, injury of the vessels, injury of neighbouring nerves, either by stretching or by rupture, or pressure upon a nerve by the displaced bone.

In a young person, provided that the dislocation is reduced early, and that no co-existing injury of the bone is present, a complete return of the joint to its normal condition may be expected. The tear in the capsule heals, and there is no tendency to a recurrence of the dislocation unless one of the main ligaments has been torn and failed to unite, or some important muscle severely damaged. When a bony process has been fractured, a return to the normal will only occur if this process has been kept in its correct position and has united firmly.

In older patients a dislocation is apt to be followed by the occurrence of osteo-arthritic changes in the joint, particularly if any injury to the articular surfaces has taken place. When muscle attachments have been torn from the bone at the time of occurrence of the dislocation, there may be a tendency to the subsequent growth of masses of bone in the muscle (traumatic myositis ossificans). This condition is particularly frequent after dislocations of the elbow.

**Symptoms and signs.**—The most important evidence of the presence of a dislocation is an alteration in the position of the articular ends of the bone from the normal. If the head of the humerus can be seen or felt below the coracoid process, or posteriorly beneath the spine of the scapula, and if palpation beneath the acromion shows that the head of the humerus is not in its normal situation, the occurrence of a dislocation is proved. Similarly the palpation of the head of the femur upon the dorsum ilii is the best proof of the existence of a dislocation of the hip.

It is often impossible to make certain of the diagnosis in such a simple

manner, because of the amount of swelling around the bone and of the pain induced by deep palpation. It may then be necessary to trust to less certain signs until such time as the patient is under an anæsthetic. Of these signs the occurrence of a characteristic deformity is the most important.

The position of the upper end of the displaced bone may necessitate a particular alignment of the shaft, which proves the occurrence of a dislocation. In a dorsal dislocation of the hip the head of the femur lies upon the dorsum ilii behind the acetabulum. This necessitates a flexion, adduction and internal rotation of the thigh, which is characteristic. Conversely the alignment of the shaft of the bone may be used as a means of inferring the position into which its upper end is displaced.

In some cases, when a certain amount of mobility remains in the dislocated joint, an alteration in the apparent length of the bone in different positions may assist in the diagnosis. Thus, in a sub-coracoid dislocation of the shoulder the head of the humerus lies considerably internal to its normal position. When the arm hangs by the side the length is but little different from that on the normal side, but when the arm is abducted, to a right angle, the humerus appears considerably shortened.

In many dislocations there is an immediate complete loss of mobility. In others, however, some mobility remains, but movements in particular directions are rendered mechanically impossible. Dugas's test for a dislocation of the humerus is an example of the utilisation of loss of movement in a particular direction as an assistance in the diagnosis of dislocation. Whenever there is a doubt as to the occurrence of a dislocation an X-ray photograph should be taken to complete the diagnosis.

**Reduction of dislocations.**—The sooner dislocations are reduced the better. Reduction may be possible up to the end of two months, but it may not be desirable to attempt reduction as late as this, because pathological changes may have taken place which render the manipulation dangerous.

The difficulties of reducing dislocations are chiefly the opposition by muscular spasm and the difficulty of finding the opening in the capsule. Powerful ligaments present both a difficulty and an assistance. Most manipulative methods of reducing dislocations have been worked out upon the principle of utilising tightened ligaments in order to exert leverage upon the displaced bone. Bigelow divided dislocations of the hip into regular and irregular. In the former the Y-shaped ligament is intact, in the latter it is ruptured. The reduction of the regular dislocations depends upon manipulations in which the Y-shaped ligament is used as a means of levering the head of the bone back into the acetabulum. In irregular dislocations of the hip, and in other dislocations in which the most powerful ligaments of the joints are ruptured, reduction is usually easy.

Immediately after a dislocation has occurred reduction may be simple and may be possible without an anæsthetic. After an hour, or less, muscle contraction opposes reduction, and anæsthesia should invariably be used.

There are three chief methods of reduction :—(1) By manipulation, the actual movements of which have been carefully worked out for each dislocation, depending upon the ligaments which are untorn, and the muscles which oppose reduction ; (2) by traction, a method which has been largely displaced by manipulation, so that it is now used chiefly in irregular dislocations ; and (3) in certain particular joints, such as the sterno-clavicular, by direct pressure upon the displaced bone.

**After-treatment of dislocations.**—In most cases, when a dislocation has once been reduced there is no liability to an immediate recurrence of the

displacement provided that the particular movement that originally produced the dislocation is avoided. Therefore complete fixation of the joint is only necessary in special cases when it is evident that some important ligament or muscle has been torn, or when there has been an accompanying fracture. The position of fixation is, then, that which will maintain the injured ligament or muscle free from strain, or will keep the fractured bone in proper position. In ordinary cases rest in a sling in the case of the upper limb, or in bed in the case of the lower limb, is sufficient.

Effusion of blood should be reduced to a minimum, and absorption of that already present should be promoted. For this purpose a firm bandage applied over a thick padding of cotton wool (compression bandage) is always useful in situations in which it can be applied. Gentle massage should be used as early as possible, and the patient's own active movements through a small range should be encouraged from the first. Care must always be taken that movements are not forced, particularly that movement which would tend to reproduce the dislocation, such as abduction and elevation of the shoulder. Only after a month may any considerable force be used. In young people return of movement is rapid; if it is not, some additional injury or a superadded inflammatory condition may be suspected. The liability of dislocations of the elbow to be followed by myositis ossificans has already been mentioned. For this condition rest is essential. After a month force gently applied under an anæsthetic may be used in the attempt to regain any special movement that is limited, but, as a rule, a skiagraph should be first taken.

When functional use returns a careful examination for abnormal mobility due to rupture of a ligament or muscle should be made. If such abnormal mobility is present a supporting appliance which prevents it may be required for a prolonged period.

**Unreduced dislocations.**—When a dislocation has been left unreduced the blood which has been extravasated into the joint and around the displaced bone soon commences to organise, fibrous tissue eventually being formed. The joint cavity may thus soon be filled with scar tissue, and if the capsule of the joint lies in contact with it, it may thus become adherent. At the same time fibrosis occurs around the displaced bone. The articular surface of this bone, however, if it is undamaged, may not become adherent, but may form around it a new false joint, with a small synovial cavity and a surrounding capsule. If movement occurs in this false joint new bone may be thrown out around so as to form a new socket. In this way a new shallow socket for the head of the femur may develop upon the dorsum ilii, or a new socket for the head of the humerus beneath the coracoid process. The range of movement in such a false joint varies greatly. There is more likely to be considerable mobility if the patient is young.

When the articular surface of the displaced bone has been damaged, erosion of the cartilage, and eventually fibrous or bony ankylosis, may result. In addition adhesions of the displaced bone to surrounding parts may be very considerable, and this may include adhesions of important structures. In an unreduced sub-coracoid dislocation of the shoulder, adhesions of the head of the humerus to the axillary nerves and vessels may form. If the dislocation has resulted in a considerable loss of function of the limb, a disuse-atrophy of the dislocated bones may also follow.

All these pathological changes will indicate the difficulties and dangers of attempts at late reduction of a dislocation. There is a danger of injury to the surrounding parts and of fracture of the atrophied bone. Even if reduction

can be secured, fibrosis which has taken place in the original joint will often be so great as effectually to prevent a complete return to normal.

**Operative treatment of dislocations.**—In recent cases operative treatment should be carried out whenever reduction of the dislocation is impossible. In most joints the operation will consist of an exposure of the joint by the most accessible route and reduction of the dislocation by leverage. The objects of the operation will be to discover the obstruction to reduction, so that this may be overcome, if possible, by some particular manipulation. If the obstruction cannot be so overcome, it may be necessary to divide a ligament or a muscle.

In the dislocation of complete bones, such as the astragalus and semilunar, reduction even by operation is seldom possible. It may then be necessary to excise the displaced bone.

In late cases an exploration of the joint may be carried out to see whether reduction is practicable or not; unless the original joint cavity is found in a reasonably healthy state, reduction will probably yield a bad result, the mobility remaining being small in amount and often painful, and osteo-arthritic changes being liable to supervene.

In most cases of unreduced dislocation, the alternatives presented are the following:—(1) Leaving the false joint and increasing its mobility by physical treatment; (2) leaving the false joint and altering the alignment of the limb by an osteotomy; (3) excision or arthroplasty of the joint; (4) arthrodesis.

**Pathological dislocations.**—By a pathological dislocation is meant one which has occurred without violence, because of some pathological change in the joint or in the surrounding structures. There are several varieties of pathological dislocations:—

1. *Dislocation by distension.* In an acute arthritis, for example, a pneumococcal arthritis, or an arthritis occurring in an acute fever, the capsule of the joint may be softened and distended, so that a dislocation occurs without violence as the patient lies in bed. A similar dislocation very occasionally occurs in the hip-joint in the early stages of tuberculosis of the joint.

2. *Dislocation by erosion.* The more common variety of dislocation in the hip-joint in tuberculous disease is due to erosion of the articular surfaces by caries, so that the head of the femur slips up on to the dorsum ilii.

3. *Paralytic dislocations,* due to the unopposed action of muscles. In infantile paralysis, a dislocation of the head of the femur on to the dorsum ilii occasionally takes place when the gluteal muscles are completely paralysed, the ilio psoas and adductors flexing and adducting the hip and driving the head of the femur backwards and upwards. In spastic paralysis an extreme flexion and adduction of the hip by muscular spasm occasionally produces a dislocation; in obstetrical paralysis of the upper limb, a dislocation or subluxation of the head of the humerus backwards occurs in a considerable proportion of cases, as a result of the pull of the pectoralis major in front of the joint, and of the absence of support to the back of the joint due to paralysis of the supra- and infra-spinati.

**Congenital dislocations** will be found to be described in the section on deformities.

## Dislocations of Special Joints.

**Dislocations of the jaw.**—Dislocations of the jaw are frequent. In almost every case the displacement of the condyle of the jaw is forwards, although there are a few reported instances of displacement backwards and of displacement outwards.

The ordinary form is usually produced by muscular action, the mouth being opened very widely, as in yawning, laughing, etc. Occasionally external violence produces the dislocation, the mouth being either forcibly opened, as for example by a dentist, or a blow being struck upon the jaw whilst it is in the open position. It is generally considered that when the mouth is widely opened, the condyle of the jaw rests upon the summit of the *eminentia articularis*, and that when a dislocation occurs it passes in front of this point. As the condyle moves forwards in opening the jaw it is accompanied by the fibro-cartilaginous meniscus, and the external lateral ligament of the joint is rendered tense. It is uncertain whether, in a dislocation, the condyle carries the meniscus with it or not. In the dislocated position the external lateral ligament lies behind the condyle and is tense, and until it is stretched or relaxed it will not allow the condyle to repass it and to return to its normal position.

In bilateral dislocation the mouth remains symmetrically open, the lower jaw is immovable and projects forwards beyond its normal position, there is a slight depression marking the empty glenoid cavity, and the condyle can be felt in front of this. The masseter and temporal muscles are usually tense. If the dislocation is unilateral the chin is turned towards the normal side.

The dislocation can be readily reduced by a downward and backward pressure upon the posterior part of the alveolar margin over the molar teeth, whilst the chin is raised. The method usually adopted is to protect the thumbs by wrapping them in lint and to insert them against the lower molar teeth in order to exert the necessary pressure. Reduction usually takes place with a snap.

FIG. 247.—Dislocation of the sternal end of the clavicle forwards. (Bryant's Surgery.)

After reduction the mouth should be kept closed by a bandage and only soft food allowed for two or three weeks. There is a very decided tendency to recurrence of the dislocation, which will best be avoided by careful rest after the first accident.

**Dislocations of the clavicle.**—*Sternal end.*—The inner end of the clavicle may be dislocated forwards or upwards or, very rarely, backwards. A complete dislocation of the clavicle is uncommon, a partial dislocation frequent. The chief strength of this joint is due to the sterno-clavicular (rhomboid) ligament, and to the inter-articular fibro-cartilage which is attached below to the cartilage of the first rib, above to the margin of the articular surface of the clavicle.

The forward and upward dislocations are produced by a force applied to the outer end of the clavicle, such as a blow or a fall upon the front or the top of the shoulder. A blow upon the front of the shoulder may lever the inner end of the clavicle forwards, or one upon the top of the shoulder may lever it upwards. A backward dislocation is most likely to be caused by a direct blow upon the front of the clavicle. In the usual form of dislocation the inner extremity of the clavicle is more prominent than on the other side, but its articular surface is still partly in contact with the corresponding surface of the sternum. The deformity is limited to this prominence of the bone, and there is no shortening of the shoulder. In a complete dislocation the inner end of the clavicle lies in front of the sternum and the shoulder is shortened. The rhomboid ligament and inter-articular fibro-cartilage are probably only ruptured in complete dislocations.

In a complete upward dislocation the inner end of the clavicle lies in the supra-sternal notch, and in a backward dislocation it lies between the sternum and the trachea. In either of these dislocations there may be considerable dyspnœa.

Reduction of the displacement is carried out in all cases by outward and backward traction upon the shoulder and manipulation of the bone into place. In the usual forward subluxations reduction is simple, but it is practically impossible to keep the bone completely in position. The best that can be done is to support the elbow and exert pressure upon the inner end of the clavicle by means of a felt pad and strapping. Practically always some undue mobility and prominence of the inner end of the clavicle remains.

In the rare upward and backward displacements reduction has, as a rule, been found impossible—at least without an exploratory incision. Failure to reduce a dislocation of the inner end of the clavicle leaves no ultimate disability.

*Acromial end.*—The acromion may be dislocated upwards or downwards in relation to the clavicle. The upward displacement is very rare—the downward displacement less so. A partial dislocation in the latter direction is not very uncommon. The latter condition results from a fall upon the shoulder, the arm hangs by the side and appears lengthened, pain being referred to the site of the joint. The outer end of the clavicle is unduly prominent and there is a depression external to it. It may be impossible to determine whether there is a dislocation or a fracture of the tip of the acromion until an X-ray photograph has been taken.

Reduction can be easily carried out by drawing the shoulder outwards and backwards and pressing downwards upon the clavicle. Complete maintenance of this corrected position is practically impossible and some undue prominence of the outer end of the clavicle always persists, causing, however, no disability.

The method of fixation which best diminishes ultimate deformity is by supporting the elbow and exerting pressure upon the outer end of the clavicle. A simple way of securing this is by passing a piece of strapping under the flexed elbow, bringing it up in front and behind the shoulder and crossing it over a felt pad applied to the outer end of the clavicle, carrying the arm in a sling. If it is important to avoid deformity the strapping should be maintained for a fortnight or even longer, but if a quick recovery of use is more important, exercise of the arm may be allowed after a few days.

Several cases of complete dislocation of the clavicle have been recorded, the sternal end being dislocated forwards and the acromial end upwards. The condition is only of interest as a surgical curiosity.

**Dislocations of the shoulder-joint.**—The shoulder-joint is specially liable to dislocation, because the glenoid cavity is shallow, the capsule of the joint very lax and the ligaments not particularly strong. The strength of the joint depends entirely upon the muscles which surround it. Although this inherent weakness of the shoulder joint is generally given as the reason for the occurrence of dislocations, it is probable that the true cause lies in the fact that when the shoulder is widely abducted the neck of the humerus comes into contact with the tip of the acromion, and that further abduction produces a leverage which tends to bring the head of the bone downwards to an extent which must rupture the capsule and produce a dislocation.

The majority of dislocations are produced by indirect violence, such as a fall upon the outstretched arm. Muscular action may, however, be a factor—most often in recurrent dislocations.

Dislocations of the shoulder are named according to the position in which

the head of the humerus lies. It is probable that in every cause of traumatic dislocation the primary displacement of the head of the humerus is downwards and forwards, the mechanism of production being the leverage already mentioned. If the arm is then allowed to fall to the side, the head of the humerus goes forward and lies beneath the coracoid process (*sub-coracoid dislocation*). If the head of the humerus remains in the position to which it is first displaced, it lies close below the margin of the glenoid cavity (*sub-glenoid*). If it is driven inwards by a force applied to the elbow, which has continued to act after the initial dislocation has occurred, the head of the humerus may come to lie internal to the coracoid process in a *sub-clavicular* position. Finally, a force which drives the dislocated head backwards may bring it into a position beneath the spine of the scapula (*sub-spinous*).

One other form of dislocation is described — *luxatio erecta*. The arm remains abducted beyond a right angle, the head of the humerus lying beneath the glenoid fossa and pointing into the axilla. This is probably the initial position of displacement in which no secondary movement of the head of the bone has taken place.

Of these different forms of displacement the sub-coracoid is far the most common, the sub-glenoid next, the others being rare.

In all dislocations the capsule is torn upon its inferior aspect, the attachment of the sub-scapularis being often damaged. The amount of damage to other muscles is uncertain.

Fig. 248.

Fig. 249.

Fig. 250.

Fig. 251

Figs. 248, 249, 250, 251.—Various forms of dislocation of the humerus. (Prof. Flower's models.)

The general signs of a dislocation of the shoulder are that, following an injury such as a fall upon the abducted arm, there is loss of mobility in the joint, with pain and the onset of swelling. The arm is held in a fixed position, which depends upon the variety of dislocation present. Usually a small amount of mobility remains, but this is accompanied by a greater or less degree of pain.

In the usual sub-coracoid dislocation the arm is held slightly abducted, the shoulder is flattened, a depression existing below the acromion, where the head of the humerus should normally lie It may be possible to press a finger deeply into this region and to feel the glenoid cavity. The front of the shoulder, below the point of the coracoid process, is unduly prominent. The head of the humerus may be felt in this situation and found to rotate under the finger when the arm is gently rotated by twisting the elbow. In a thin

person this direct evidence that the head of the humerus is absent from the glenoid fossa and can be felt lying beneath the coracoid is the best proof of the occurrence of a dislocation, but if the patient is muscular or fat, palpation may be difficult and it may be necessary to rely upon less certain signs.

Hamilton's test consists in applying a straight ruler to the outer side of the arm. This is simply a method of rendering the depression below the acromion more evident.

Callaway's test consists in measuring by passing a tape beneath the axilla and over the acromion. The circumference thus obtained is increased by two inches or more when a dislocation is present. This increase is due to the fact that the axillary folds are lowered, and that the measurement includes the prominence formed by the dislocated end of the humerus.

In Dugas's test the hand is placed upon the opposite shoulder; it is then impossible for the elbow to be brought to the side if a dislocation of the shoulder is present. This test depends upon the fact that in all dislocations there is a fixed abduction of the joint. In spite of this abduction the elbow can be brought to the side by a scapular movement, provided that the arm is not internally rotated; placing the fingers upon the opposite shoulder by rotating the arm prevents adduction.

In a dislocation of the shoulder uncomplicated by fracture the line of the shaft of the bone continued upwards must lead to the head and demonstrate its position. If this is borne in mind it will usually be comparatively simple to locate the head of the humerus and to feel it, confirming its nature by gently rotating the arm. It must be remembered, however, that a dislocation may be complicated by a fracture, in which case the evidence derived from the direction in which the shaft points will be illusory.

In sub-glenoid dislocation the arm is more abducted, the distance from the acromion to the external epicondyle is definitely increased, and the hollow below the acromion is very evident. The head of the humerus may be felt in the axilla *Luxatio erecta* is a variety of this dislocation.

In sub-spinous dislocation the head of the bone can be felt and often seen forming a prominence posteriorly beneath the spine of the scapula. The arm is abducted and the elbow carried forwards.

Sub-clavicular dislocation is very rare; the head of the bone can be felt and seen beneath the clavicle internal to the coracoid process. The arm is considerably abducted and is shortened.

The *diagnosis* of a dislocation of the shoulder is in most cases comparatively simple, rendered more difficult, however, in a very muscular or a very fat patient. Fracture of the neck of the humerus, separation of the upper epiphysis, fracture of the neck of the scapula or glenoid cavity, and simple sprains of the joint may, any of them, require to be distinguished from a dislocation. If reliance is placed chiefly upon absolute signs—that is, the determination by palpation that the head of the humerus is not in the glenoid cavity, but is in some other situation—mistakes will seldom be made.

It is most important that a fracture coexisting with a dislocation should be diagnosed. Whenever the head of the humerus is displaced from the glenoid fossa, and the direction of the shaft of the bone does not correspond with the displacement present, an X-ray photograph should be taken before treatment is carried out. As fractures of the tuberosities are not excessively rare in dislocations of the shoulder, it is a sound principle to take an X-ray of every dislocation of the shoulder after reduction.

*Reduction* of a dislocation of the shoulder may be simple or extremely difficult. When the patient is seen immediately after the accident and is in

considerable pain, it may be worth while attempting immediate reduction without the administration of an anæsthetic. At this stage the muscular rigidity is not very great, and should reduction be possible the patient's relief is immediate. The attempt, however, should not be prolonged. If it fails an anæsthetic should be administered before more determined efforts are made.

Two chief methods of reducing a dislocation of the shoulder are used. The manipulative method is usually known as the method of Kocher; the surgeon grasps the arm by the elbow and wrist, abducts the limb and rotates it outwards until the head of the humerus forms a prominence beneath the anterior part of the deltoid. Maintaining this external rotation, the elbow is brought forwards, upwards and inwards until it comes over the middle line of the body, then the arm is rotated inwards, the hand being brought across the opposite shoulder. The first part of the manipulation—that is the external rotation—should be carried out slowly and deliberately with a little gentle traction

FIG. 252.—Kocher's method of reducing a dislocation of the humerus. Phase 1.

FIG. 253.—Kocher's method. Phase 2.

until the muscles are felt to relax. The rest of the movements are then completed in a steady sweep, not hurried, but not interrupted or jerky. The object of this manipulation is, first, by external rotation, to relax the tight anterior muscles; next, by bringing the elbow forwards and upwards, to lever the head of the humerus down to the lower part of the joint where the gap in the capsule lies, and finally, by means of the internal rotation, to pass the head of the humerus through the gap into the glenoid fossa. If this manipulative method fails, direct traction should be used. The surgeon places his foot or knee in the axilla to make a point of counter-pressure and pulls the arm directly downwards in the line in which it is lying. At the moment of fullest extension, when the muscles have been relaxed, the foot in the axilla exerts an outward pressure against the neck of the bone, which levers the head into a position from which it can pass directly into the joint. If these methods fail, reduction by incision will be indicated.

The use of other methods of leverage and of pulleys, rings, etc., which were justifiable before the days of aseptic surgery, can no longer be justified when an incision carries practically no risk of sepsis, for they all involve consider-

able risk of injury of the axillary vessels and nerves, or of the production of a fracture.

When a dislocation of the humerus has been reduced, the arm should be kept in a sling for a few days and then used, the patient being warned not to carry out movements of abduction or elevation for the first week. Massage and active movements may be started the day after the reduction. Abduction and external rotation, however, should not be forced until after three weeks from the injury.

In young persons a complete restoration of function is to be expected, provided that there has been no associated injury to the bone. If limitation of movement persists after six or eight weeks, the joint may be carefully stretched under an anæsthetic.

Dislocation of the shoulder may be complicated by injury of the axillary nerves and less often of the vessels. Injury of the nerves may be of any degree of severity and may involve one or all the nerves. There may be a simple paralysis of the deltoid due to stretching of the circumflex nerve, or

FIG. 254.—Kocher's method. Phase 3.

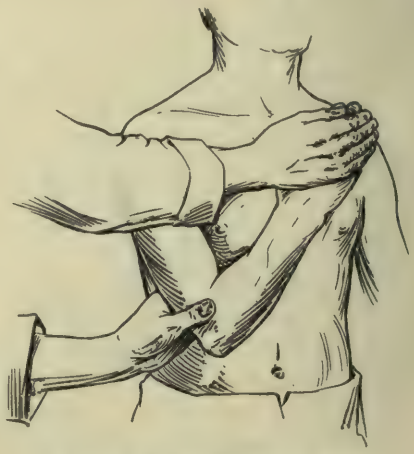


FIG. 255.—Kocher's method. Phase 4.

there may be a complete paralysis of the entire upper limb. In almost every case in which this complication occurs ultimate recovery takes place without operative interference, but if the initial injury has been severe, then recovery may necessitate a period of as much as two or three years' treatment by massage and electrical stimulation.

Fracture of the neck of the humerus as a complication of dislocation of the shoulder has already been mentioned. The diagnosis depends upon the discovery that the head of the humerus is displaced from the glenoid fossa and that the line of the shaft of the bone does not lead directly towards this displaced head. Confirmation of this diagnosis by an X-ray photograph is essential. This complication is embarrassing and its treatment difficult. If a good result is to be obtained, an early diagnosis, reduction of the head of the bone into the joint, and its subsequent treatment as for a fracture of the surgical neck are the only methods than can give a satisfactory functional result. It may be possible to reduce the head of the humerus by direct manipulation through the axilla whilst the patient is anæsthetised. If this fails an immediate incision should be made down to the joint and the reduc-

tion carried out by leverage. If the upper fragment is too small to be held with simple bone-holding forceps, it may be drilled in order that a hook may be inserted and traction exerted. After closure of the wound the treatment will be that of a simple fracture. Considerable residual stiffness of the joint is to be expected.

The treatment of unreduced dislocations of the shoulder has already been sufficiently mentioned (see p. 606).

In certain cases there is a tendency for a dislocation of the shoulder to recur as the result of very slight violence, probably because the lower and anterior part of the capsule is left persistently torn or stretched. Sometimes these recurrences are the result of slight injuries from external violence, but in the worst cases the shoulder may dislocate at frequent intervals simply as the result of abduction, or of abduction and external rotation of the joint by the patient's own muscular effort. Usually such a recurring dislocation is easily reduced, many patients learning to carry out the manipulation for themselves. But the disability is a very serious one, particularly in a young person in whom it may prevent practically any form of active exercise.

Treatment for this condition may be carried out by the use of an appliance or by operation. The appliance consists of a leather strap around the chest and a second leather collar round the arm close below the axilla, the two being united by a short length of chain which prevents anything more than a very limited abduction of the shoulder-joint. The principal use of this appliance is that if dislocation can be prevented for a period of six months or a year, the weakened part of the capsule may close or become supported in such a way as to effect a permanent cure. This method of treatment is, however, seldom completely successful.

Various operations have been tried; those which depend upon pleating the capsule of the humerus or exsecting a portion of it have uniformly failed. The recurrence of the dislocation can, however, be prevented by an operation in which a flap consisting of a portion of the deltoid is slung beneath the shoulder-joint to cover the weakened portion of the capsule. Then when the shoulder is abducted the deltoid muscle is actively contracted, and this muscular flap, contracting at the same moment, supports the joint and prevents dislocation. The operation is done through two incisions. By a posterior vertical incision about one-third of the posterior part of the deltoid is split off from the rest and separated from its insertion, the nerve supply being carefully preserved. This separated portion is passed through the quadrilateral space under the head of the humerus and brought out through an anterior incision made over the interval between the deltoid and pectoralis major, where it is fixed to the anterior surface of the tendon of the sub-scapularis. The arm should be kept close to the side for one month after the operation and a full range of movement only allowed at the end of two months. In performing this operation for recurrent dislocation it can generally be demonstrated that there is no rent in the capsule, but that the whole of the anterior part of the latter is stretched.

**Dislocations of the elbow-joint.**—Dislocations at the elbow-joint may be divided into (1) dislocations of the radius and ulna backwards; (2) dislocations of the radius and ulna outwards; (3) dislocations of the radius and ulna inwards; (4) dislocations of the radius and ulna forwards; (5) dislocations of the ulna alone; (6) dislocation of the radius alone; (7) dislocation of the two bones in different directions.

Of these the first occurs frequently. Lateral dislocations are uncommon, although a dislocation backwards and to one side is not particularly rare.

Dislocation of both bones forward is very exceptional. Dislocation of the ulna alone is very rare. Dislocation of the head of the radius forwards is not very uncommon, and occurs as a congenital deformity.

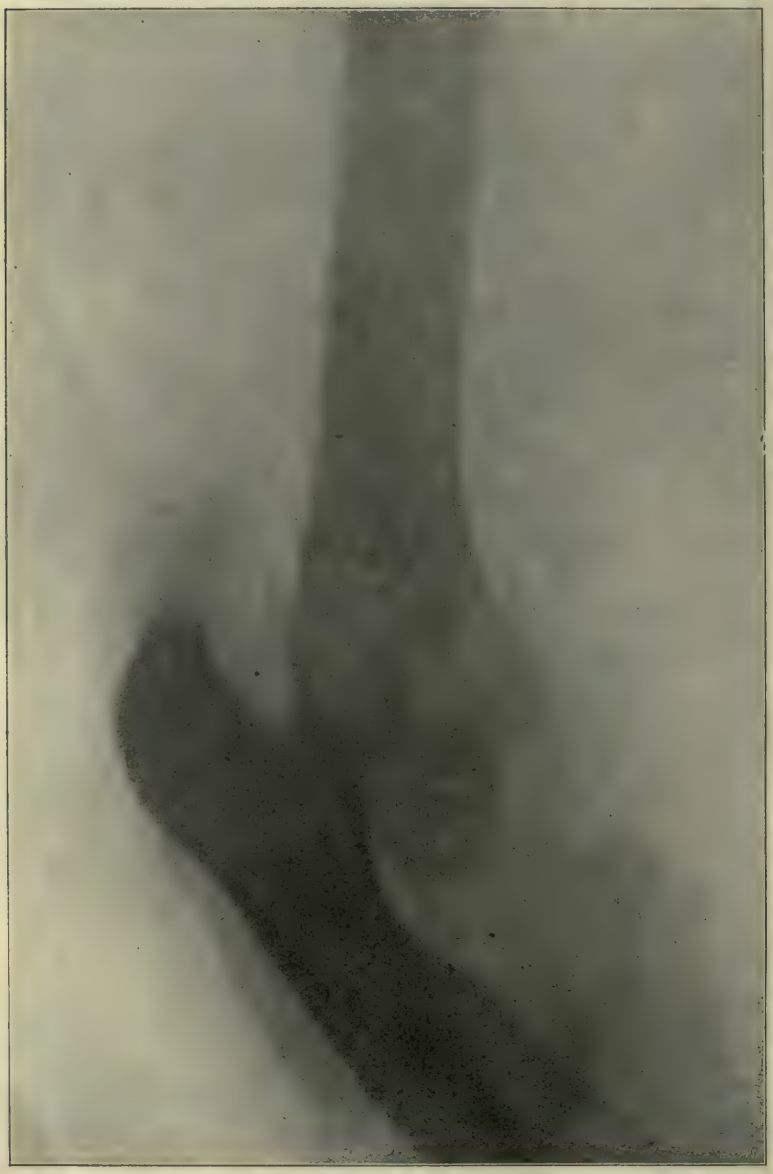


Fig. 256.—Dislocation backwards at the elbow-joint of both ulna and radius. (Skiagram taken by Dr. Hugh Walsham.)

The ordinary dislocation of both bones backwards is commonly due to a fall upon the outstretched hand. The anterior ligament and lateral ligaments are torn, the dislocation probably occurring by a movement of hyper-extension.

The elbow is held immobile and usually flexed to about a right angle. The forearm is shortened and the olecranon forms a backward projection which is characteristic. The head of the radius may also be felt behind the external condyle of the humerus. The normal relation of the condyles to the olecranon is evidently abolished, and the condyles do not move with the olecranon when slight movements of the joints are carried out. These signs will serve to diagnose the condition from a fracture of the lower end of the humerus. There may be some associated fracture, most often of the coronoid process or of the head or neck of the radius. A slight lateral displacement of the forearm bones, either to the inner or to the outer side, is not very unusual.

Reduction of the dislocation should be carried out by leverage, the object being to disengage the coronoid process from behind the lower end of the humerus, so that it can slip forward into place. If the patient is recumbent the arm should be abducted at the shoulder to a right angle, the forearm being kept horizontal. The surgeon then places his foot upon a chair and presses with his knee against the lower end of the humerus. By pressure with the knee into the angle in front of the elbow, with traction upon the forearm and gentle, continuous flexion of the elbow, the necessary leverage can then be exerted, and the dislocation is generally reduced with an evident snap. Reduction by such a method should be easy in recent cases. After four or five weeks, however, adhesions are likely to have become firm, and an amount of force may be required which is dangerous. As much force as is safe can be exerted by this method, so that the use of pulleys and other more violent methods is not advisable. In such late cases an operation for reduction is the better method ; then, should it be found that the joint surfaces are damaged so as to render it probable that the ultimate mobility will be poor, an arthroplasty of the joint may be carried out.

After reduction of dislocation of the elbow there is little tendency to recurrence of the deformity, provided that the coronoid process has not been fractured. No fixation need be used, but it is advisable to keep the arm rested in a sling and to allow a restoration of use gradually and by the patient's own muscular efforts. The use of forced passive movement is particularly liable to set up a myositis ossificans around the elbow after a dislocation of the joint.

Lateral dislocations of the elbow are uncommon. In a dislocation outwards the sigmoid cavity of the ulna lies in contact with the radial articular surface of the humerus, the head of the radius forming a prominence on the outer side, the internal condyle projecting on the inner side of the joint. In dislocation inwards the deformity is reversed. These dislocations should be reduced by the same manœuvre as that adopted for a posterior dislocation, lateral pressure being applied whilst the joint surfaces are being opened from each other by the leverage exerted with the knee.

Dislocation of both bones forwards is exceedingly rare and has occurred only in very severe accidents, some of which have resulted in the loss of the limb or in loss of life.

In many cases described as coming into this class the injury has really been a fracture of the olecranon, with a displacement forwards of the lower fragment of the ulna and the head of the radius.

In dislocation of the head of the radius forwards there is a hollow posteriorly below the external condyle, where this bone should lie, and the head of the radius can be felt lying in front of the condyle. On gently pronating and supinating the forearm, rotation of this displaced head of the radius can be detected. Flexion of the elbow is mechanically hindered by contact of the

bead of the radius with the humerus, and the orbicular ligament will probably he torn.

In diagnosing this injury it must be remembered that a forward displacement of the head of the radius is a not uncommon congenital deformity. If the condition is really a traumatic and recent one, reduction by simple backward pressure, combined with traction on the hand, will be possible, but it will almost certainly be impossible to prevent the deformity recurring as soon as the pressure is relaxed. In a case in which reduction can be carried out the arm should be fixed with the elbow fully flexed for a period of three weeks in order to make sure that full flexion of the joint is restored.

Fig. 257.—Incomplete lateral dislocation of the elbow outwards.

The head of the radius may also be displaced outward, so that it lies external to the condyle of the humerus, the orbicular ligament being ruptured. Here, again, retention of the corrected position is generally impossible, but as the displaced radius will not interfere with the elbow movement the persistent displacement is less important.

In unreduced dislocation of the head of the radius forward, it may be considered advisable to excise the head of the bone in order to restore full flexion of the elbow-joint. The patient should, however, be warned that by this operation he will gain movement but will lose considerably in the strength of the forearm.

Dislocation of the ulna alone is extremely rare. In the recorded cases the displacement has generally been backward or backward and inward, the carrying angle at the elbow being abolished.

Divergent dislocations of the radius and ulna are also very rare. In one group the radius is displaced in front of the humerus, and the ulna behind it; in the second group the ulna lies on the inner side of the humerus, the radius on the outer side. These have all resulted from injuries involving very considerable violence.

**Dislocations of the inferior radio-ulnar joint.**—It is doubtful if a true traumatic dislocation of this region occurs. A backward displacement of the ulna which is hypermobile and can be pressed forward until it comes into a more normal relationship with the radius is not very uncommon. It is most marked as a part of the deformity classed as spontaneous subluxation of the wrist of Madelung (see p. 244).

**Dislocations of the wrist-joint.**—Dislocations of the wrist-joint are very

uncommon, particularly if cases in which fracture has occurred are strictly excluded. The carpal bones may be displaced on to the dorsal surface. They will, however, usually carry with them the styloid processes of the radius and ulna. The diagnosis from Colles's fracture will be made by the fact that the prominence on the dorsal surface is at a lower level in a simple dislocation, and from a mid-carpal fracture dislocation, because the prominence in the latter case is at a still lower level and is much less marked. An X-ray examination will, however, always be required.

In simple dislocation reduction has usually been effected with comparative ease by traction upon the hand and direct forward pressure on the carpus. The wrist should be fixed afterwards in an extended position.

**Dislocations of the metacarpals and phalanges.**— Of dislocations of the metacarpal bones from the carpus the most important is that of the first metacarpal backward upon the trapezium. This dislocation is often incomplete; the posterior edge of the metacarpal bone can be felt on the dorsal surface between the extensor tendons to the thumb. Movement at the affected joint is limited and painful.

In a recent case direct traction upon the thumb, combined with forward pressure, will secure reduction; the thumb should be fixed afterwards in a fully extended position to prevent recurrence.

In unreduced dislocations fairly good function is generally restored, so that operative treatment, which is almost certain to leave a stiff joint, is seldom indicated.

The first phalanx of the thumb or of any of the fingers may be dislocated from the metacarpal bone. A dorsal dislocation is the most frequent. The phalanx is usually hyper-extended at its proximal end, forming a prominence on the dorsal surface, and the diagnosis is obvious. In recent cases a reduction is generally easy by traction combined with preliminary hyper-extension of the joint

In the thumb, however, reduction may be very difficult, the difficulty being usually ascribed to the fact that the head of the metacarpal passes forward between the two heads of the flexor brevis muscle and is embraced by the short muscles of the thumb and by their sesamoid bones. In this injury reduction by an open operation should be carried out whenever manipulation has failed.

A longitudinal incision should be made on the palmar aspect over the head of the metacarpal bone until this bone is exposed. The long flexor tendon will be found to be displaced to one or other side of the head. It should be lifted forward, and an effort then made to reduce the dislocation. If this is unsuccessful it may be found that a part of the anterior capsule of the joint is tight against the dorsal surface of the head of the metacarpal. When this has been divided with a tenotome, reduction can be carried out.

In unreduced dislocations a fairly useful thumb generally results, but the joint is stiff. Efforts to restore mobility by a late reduction by operation will probably fail. The chief indication for operation at a late stage will be persistent pain. In cases in which this is present it may be desirable either to expose the joint, cut away the articular surfaces and attempt to make a new joint by the insertion of a flap, or, as an alternative, to leave the cut surfaces of bone in contact and aim at securing a bony ankylosis. The latter is the more certain way of abolishing pain.

Dislocation of the phalanges from each other gives rise to an obvious deformity and requires no special description.

**Dislocations of the hip-joint.**—Dislocation of the hip-joint is uncommon.

It most often occurs in young adults, being very rare in children; in old patients fracture of the neck of the femur is far more common.

The cause is generally a forcible abduction of the joint or a blow upon the thigh when the hip is in the abducted position, the head of the femur being driven out of the acetabulum upon the lower and inner side. As a general rule the ilio-femoral or Y-shaped ligament is uninjured. This ligament is only completely ruptured in dislocations which have resulted from a very severe violence.

The positions in which the head of the femur may lie are usually classified

FIG. 258.—Dislocation on dorsum ilii.

FIG. 259.—Dislocation into sciatic notch.

(Cooper's Dislocations.)

(*Note.*—These classical figures and those on pp. 584 and 619 are depicted upright the better to show the deformity. It is not intended that the patient should be examined in any other position than lying down.)

into regular and irregular. In the regular dislocations the Y-shaped ligament is unruptured—in the irregular it is ruptured.

The most important of the regular positions are the following:—

1. Dislocation on to the dorsum ilii;
2. Dislocation into the sciatic notch (dorsal below the tendon);
3. Dislocation into the obturator foramen; and
4. Dislocation on to the os pubis.

This constitutes Sir Astley Cooper's classification. Dislocation on to the dorsum ilii is the most common form. The head of the bone, on escaping from the acetabulum on the lower and inner side, slips round to the posterior surface, where it lies under the gluteal muscles above the tendon of the obturator internus muscle. The capsule of the joint is torn in its lower part. The only muscles ruptured are some of the small external rotators.

The position of the limb is characteristic. The hip is flexed, adducted and rotated inwards and the thigh is shortened, so that the knee lies in front of the lower end of the opposite femur. The head of the femur may be felt upon the dorsum ilii, and identified by rotating it slightly under the hand. The great trochanter lies above Nélaton's line, and the vertical measurement in Bryant's triangle is diminished or may disappear.

In dislocation into the sciatic notch the deformity is similar but less extreme. The head lies below the tendon of the obturator internus, and the injury to the posterior muscles is probably slight. The hip is adducted, flexed and rotated inwards, the head of the femur may be felt in its abnormal position posteriorly. The hip can be flexed to a right angle and the head of

FIG. 260.—Dislocation into obturator foramen.

FIG. 261.—Dislocation on the os pubis.

(Cooper's Dislocations.)

the femur can then be identified, lying very considerably behind its normal position.

Dislocations into the obturator foramen constitute the second most frequent class. The head of the femur escapes from the acetabulum in the lower and anterior part and lies upon the obturator externus muscle. The hip is abducted, flexed and everted, so that there is apparent lengthening of this limb. The head of the femur may be palpable, lying deeply under the inner part of Scarpa's triangle.

In dislocation on to the os pubis the head of the femur has passed further forward and rests below Poupart's ligament upon the pectineus muscle. The hip is more flexed, abducted and everted than in the last described group, and the head of the femur may form a visible prominence in the region of the inner half of Poupart's ligament.

The other forms of dislocation of the hip are those in which a part or the whole of the Y-shaped ligament is ruptured. They are of extreme rarity, and they most often result from injuries of great severity likely to be fatal from other causes.

Reduction of a traumatic dislocation of the hip can generally be carried out with comparative ease by using the scientific method of manipulation first suggested by Bigelow. The patient is laid upon his back upon the floor and anæsthetised. In the case of a dorsal or sciatic dislocation, the thigh is first flexed fully upon the abdomen—adduction and internal rotation being kept up. This brings the head of the femur down to the lower border of the acetabulum on its posterior surface, the Y-shaped ligament being relaxed. The limb is then abducted in the fully flexed position and at the end of abduction is rotated out. The abduction brings the head of the femur directly

FIG. 262.—Method of reducing the dorsal and sciatic dislocations of the hip by manipulation.

FIG. 263.—Method of reducing the pubic and thyroid dislocations of the hip by manipulation.

(After Bigelow.)

below the acetabulum, and the external rotation turns it into the rent in the capsule.

In the case of an obturator or pubic dislocation the manipulation is exactly the opposite. The thigh is flexed at the hip-joint in the abducted and externally rotated position. It is then adducted to the mid-line and rotated slightly in. It is comparatively easy by using excessive abduction and external rotation upon the dorsal dislocation to convert it into an obturator dislocation instead of reducing it; similarly, by an excess of the opposite movement, an obturator dislocation may be converted into a dorsal dislocation.

In recent dislocations of the hip, manipulation by these methods under anæsthesia will very seldom fail. There is very little liability to recurrence of the dislocation, no fixation of the joint being necessary. Rest in bed for a month to allow any effusion to subside, with gentle massage and active movements, should, in a young adult, restore the joint practically to the normal.

The most important complication in traumatic dislocation of the hip is an injury to the acetabular rim. This can only be diagnosed by an X-ray photograph, although it will be suspected in any case in which a dislocation which has been reduced tends to recur without any additional injury.

The treatment of such a case is by fixation with extension in a widely

abducted position in order to avoid the upward pressure against the damaged acetabular notch which occurs immediately the hip is allowed to adduct.

In unreduced dislocations of the hip attempts at a late reduction may be carried out, even up to six months or more after the injury.

The disability arising from dislocation of the hip is severe, and if reduction cannot be accomplished the alternative is excision of the head of the femur. The only risk in attempting to reduce a dislocation by manipulation at a very late stage is that of fracturing the neck of the femur. Should such a fracture be produced, it does not in any way interfere with the success of an excision of the joint.

**Dislocations of the patella.**—A true traumatic dislocation of the patella is extremely rare, if it ever occurs. Habitual dislocation is, however, not uncommon. It usually arises in children or adolescents, and is due to some anatomical abnormality in the knee-joint, which allows the patella to slip over the external condyle of the femur and lie upon its outer side. In some cases the dislocation only takes place occasionally, is accompanied by severe pain, and the patient is unable himself to reduce the dislocation or extend the knee. It may occasionally be necessary to give an anæsthetic before the bone can be replaced.

In other cases the displacement occurs whenever the knee is flexed beyond a certain point. There is then no pain, but considerable disability, because the action of the quadriceps muscle is interfered with and voluntary extension of the knee-joint is difficult or impossible.

There is a tendency for the first group of cases to develop a dislocation which occurs with greater and greater ease, so that they pass into the second class. Therefore, in the cases of occasional dislocation, the joint should be rested after each injury and the quadriceps muscle, particularly the vastus internus, should be strengthened by appropriate exercises and electrical treatment.

In the second class various operations have been suggested. These are: (1) Osteotomy of the femur, to correct the slight degree of knock-knee; (2) vertical division of the capsule of the knee-joint down the outer border of the patella; (3) pleating the capsule of the knee-joint on the inner side of the patella; (4) a transplantation of the tubercle of the tibia to a lower site so as to place a greater tension upon the patellar ligament.

Although success has been claimed for each and all of these methods, it must be acknowledged that when such alleged successes are re-examined, it is commonly found that the habitual dislocation continues to occur.

**Dislocation of the knee.**—Dislocations of the knee-joint are very rare. They are due to very severe violence—most often to a forcible hyper-extension which ruptures the crucial ligaments. The tibia may be displaced forwards, backwards or to either side, the diagnosis being evident.

Reduction is carried out by extension upon the leg, combined with manipulation under an anæsthetic. The limb should be fixed afterwards in plaster of Paris in a straight position for a period of at least six weeks, in the hope that the ruptured ligaments may unite. The chief functional disability following such severe injuries of the knee is that due to the abnormal mobility resulting from injury to the crucial and lateral ligaments.

**Dislocations of the ankle and tarsus.**—A true dislocation of the ankle without fracture is extremely rare. The most frequent dislocations in the ankle region are complete dislocation of the astragalus and a dislocation of the rest of the foot from the astragalus (sub-astragaloid dislocation). Both of these result most often from a fall from a height on to the foot when it is in the

plantar-flexed position. Formerly very rare, they have become comparatively common as the result of flying accidents.

Complete dislocation of the astragalus most often occurs in a forward and outward or forward and inward direction. Dislocations backward are extremely rare. The mechanism of the injury is probably a crushing blow upon the under surface of the heel whilst the foot is forcibly plantar-flexed; the os calcis and tibia are driven together, and the astragalus is shot out in a forward direction by compression. The bone may be uninjured or it may be comminuted or fractured through the neck. The head of the bone may be driven through the skin on the anterior surface of the ankle, rendering the dislocation compound.

In complete dislocation the diagnosis will usually be obvious, the whole of the bone being palpable in front of the ankle.

Reduction of the dislocation is impossible, and the best treatment is the entire removal of the displaced bone. As the lower articular surfaces of the tibia and fibula are too narrow to enable them to articulate accurately with the upper surface of the os calcis, whenever an astragalectomy has to be performed, Whitman's operation should be completed (see p. 266).

**Sub-astragaloid dislocations of the foot.**—Sub-astragaloid dislocation is produced in a similar way to the last-mentioned injury. Most often the foot is displaced outward, or backward and outward from beneath the astragalus, so that the result is to produce a very severe valgus deformity of the foot.

There is often an associated injury of the internal malleolus, and at first sight the appearances resemble those of a Pott's fracture. On careful examination, however, it will be found that the os calcis lies too much to the outer side of the astragalus, and that a finger can be inserted beneath the latter bone.

If the dislocation is complete the head of the astragalus will have come out of the concavity of the scaphoid and project in front of the ankle. Often, however, this joint remains intact, so that there is a rotation of the foot, the heel being displaced outward, the anterior part of the foot inward. This complication renders the diagnosis still more difficult. In most cases of sub-astragaloid dislocation the diagnosis has not been made at an early stage, and early reduction has consequently not been attempted. It is uncertain, therefore, whether such reduction is possible. It would appear, however, to be worth attempting reduction under an anæsthetic by first forcibly everting the foot and pressing it backwards to increase the deformity and disengage the inner edge of the os calcis, subsequently drawing the foot forward and inward in an attempt to secure complete reposition. In irreducible cases and in cases diagnosed late, removal of the astragalus is the only available method of treatment that promises a useful foot.

# Section XIII.

## INJURIES AND DISEASES OF THE VERTEBRAL COLUMN.

### Injuries of the Vertebral Column and Spinal Cord.

The **spinal cord** terminates at the level of the lower border of the first lumbar vertebra and receives *almost* adequate protection from injury (1) by the vertebral column which encloses it, (2) by the membranes which surround it, and (3) by the cerebro-spinal fluid in which it is bathed. All these factors tend to protect the cord during the various extensive movements of the spinal column. There are, however, certain weak links in the chain. The movements of the column are free in the cervical and lumbar regions, but the dorsal, by reason of the imbrication of the articular processes and the splicing of the ribs, is relatively immobile. The stress, therefore, of all the more extensive movements falls on the junction of the *cervical and dorsal* segments on the one hand and the *dorsal and lumbar* on the other. Consequently, it is in the cervico-dorsal and dorsi-lumbar regions that fractures and fracture-dislocations are most frequently observed.

A *pure dislocation* is a rarity and only occurs in the cervical region where the articular processes are placed more or less horizontally in relation to one another.

**Fracture-dislocations** are the rule in all other parts of the vertebral column, though minor degrees of injury are seen, such as fractures of the spinous processes, laminæ, etc. In fracture-dislocations the displacement of the parts is considerable, though such displacement may be of a momentary nature only, the parts snapping back into position immediately after the injury or after some movement on the part of the patient. In the majority of cases, however, the parts remain displaced. In addition, further deformity will be produced if the patient is roughly handled or an attempt made to place him on his feet.

The upper segment almost invariably falls *forwards* in front of the lower portion of the vertebral column. The displacement also being considerable, it is the rule for the spinal cord to undergo, at the moment of injury or afterwards, considerable destruction—often complete division and pulping. The main dangers incident to fractures and fracture-dislocations are almost entirely dependent on the associated damage to the soft parts, and experience tells us that such lesions are the rule.

Even when the cord is only partially injured, the conditions are little better, for, in addition to the actual destruction of the cord itself, the injury is always accompanied by hæmorrhages in and around the cord. The cord and its membranes are richly supplied with blood-vessels; laceration of these produces hæmorrhages into the substance of the cord (*hæmato-myelia*) and hæmorrhages in relation to the membranes (*hæmato-rachis*), both of which complications are associated with concussion of the cord, a condition considered later. Hæmato-myelia may be regarded as analogous to contusion and laceration of the brain, whilst hæmato-rachis to all intents and purposes corresponds to extra- and sub-dural hæmorrhages.

On further comparison of skull and spine injuries it will be seen that the osseous lesion is comparatively unimportant in both cases. It is the damage to the brain and cord which matters, and in fractures and fracture-dislocations of the vertebral column the prognosis hinges almost entirely on the presence and extent of associated injury to the cord.

*Symptoms.*—Whatever the degree of cord injury, the symptoms arising in fracture and fracture-dislocation of the spine must be considered under two headings—those referable to the *osseous lesion*, and those directly referable to the *cord injury*.

FIG. 264.—Specimen showing fracture-dislocation of the vertebral column, with crushing of the cord. The upper segment of the vertebral column has fallen forwards. (St. Bartholomew's Hospital Museum.)

1. **Symptoms referable to the osseous lesion.**—Pain at the seat of injury, swelling and bruising. The pain is both *local* and *referred*—in the latter case along the course of any spinal nerves that may be crushed at their emergence from the intervertebral foramina. The more localised pain is dull in character, with exacerbations on attempted movement. The bruising may be very extensive and large hæmatomata may exist. There may be some irregularity of the spinous processes, with pain on examination and even crepitus (though no definite attempt should ever be made to elicit this symptom).

The nature and extent of the osseous lesion should always be investigated by means of X-rays.

2. **Symptoms directly referable to the lesion of the cord.**—These vary according as to whether the cord lesion is of the nature of a *complete transverse lesion* or of a more *partial* character.

(A) **Symptoms resulting from a total transverse lesion of the cord.**—*Motor phenomena.*—Immediate paralysis of all muscles supplied by nerves emerging *below* the level of the lesion, the paralysis being of the flaccid type. Later on, if the patient survives, the paralysis may become spastic (from tract degeneration), with rigidity, contractures, and exaggeration of reflexes. The muscles waste rapidly, but there is no complete reaction of degeneration.

Immediate paralysis of all muscles supplied by the nerve or nerves emerging *at* the level of the lesion, as the result of crushing in the region of the intervertebral foramina, with rapid muscular wasting and, later, reaction of degeneration.

Twitchings, and painful cramps, of the muscles supplied by nerves coming off from the cord *immediately above* the level of the lesion, as the result of irritation from hæmorrhage into the nerve-sheaths and around the nerve-trunks.

*Sensory phenomena.*—Immediate loss of all forms of sensation *below* the level of the lesion. This anæsthetic area usually presents a well-defined upper border, but owing (1) to the very oblique intradural course of the spinal nerves,* and (2) as a result of the intimate anastomosis between any three consecutive nerves (Sherrington), the uppermost limit of anæsthesia is nearly always rather *below* the actual level of the lesion. Thus, if the anæsthetic area corresponds to the level of the twelfth dorsal spine the cord is probably injured at the level of the tenth dorsal vertebra. Again, owing to the free overlapping and anastomosis between the posterior branches of the spinal

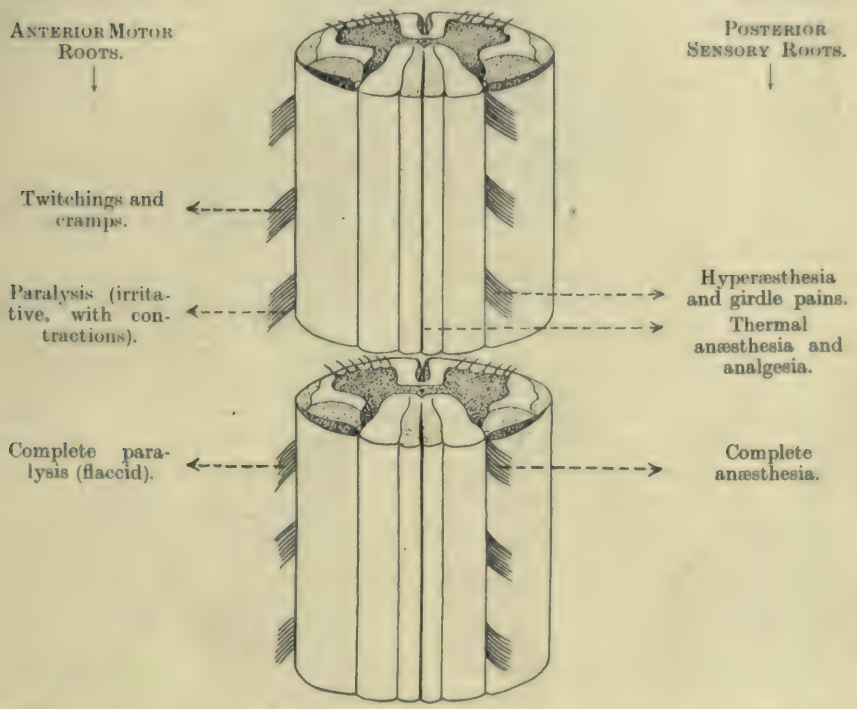



Fig. 265.—Schematic representation of the motor and sensory changes occurring after complete division of the spinal cord.

nerves, the upper limit of anæsthesia runs almost at *right angles to the long axis of the body*, not obliquely, as might be expected.

*Immediately above* this anæsthetic area there is often a narrow zone of *thermal anæsthesia and loss of pain sensation*, due probably to the extension of hæmorrhage up the central neural canal, with compression of the surrounding grey matter.

*Immediately above* this, again, there is another narrow zone of *hyperæsthesia*, resulting from intradural irritation of the posterior spinal roots, from blood extravasation into their sheaths and around their trunks. In consequence, also, of this root irritation "*girdle*" pains are frequently observed, together

* From the fourth cervical to the tenth dorsal the nerve trunks come off the cord two vertebræ higher than their own numbers. Also from the third dorsal to the ninth dorsal the spine indicates the vertebra next below. Thus the eighth dorsal nerve arises opposite the sixth vertebra, but is indicated by the fifth spine (see also p. 636).

with tingling, numbness, formication, etc., according to the distribution of the nerves affected.

*Reflexes.*—All reflexes, both superficial and deep, which are dependent on the integrity of the cord, are abolished at and below the level of the lesion. The deep reflexes are permanently lost, the superficial may return.

*The bladder.*—In all injuries of the cord *above* the level of the lumbar micturition centres it is usual to find *false incontinence* of urine (retention with overflow), the urine dribbling away continuously. In some cases, however, the bladder empties itself periodically, though perhaps incompletely. When the lumbar centres are directly involved, and when the lesion is situated *below* that level, *true incontinence* is seen, the urine dribbling away (from paralysis of the sphincters) immediately on entering the bladder.

*The bowels.*—The intestines are paralysed in all the higher lesions of the cord, from involvement of the sympathetic, with considerable abdominal distension, tympanites and obstinate constipation. When respiration is already embarrassed, this abdominal distension adds greatly to the difficulty experienced in adequate aeration of the lungs. Later on, after the administration of strong purgatives, there is incontinence of fæces (from paralysis of the sphincters) till the bowels have been thoroughly emptied, when constipation again holds the field.

*Vaso-motor and trophic disturbances.*—The vaso-motor nerves leave the spinal cord in the middle portion of its length, probably between the second dorsal and the second lumbar. There is, in consequence of an injury situated below the upper of these two levels, vaso-motor paralysis of the regions involved. The extremities are blue and cold. The tissues may be œdematous, and the joints are occasionally the seat of a chronic synovitis. The skin is dry from lack of sweating. Trophic sores are very liable to form over the more exposed parts, the sacral region, elbows, heels, and popliteal region. *Priapism* is an almost constant feature, the penis attaining a moderate degree of erection on the slightest stimulation, *e.g.*, the passing of a catheter, remaining in that condition for a prolonged period of time.

*Respiratory affections.*—Alterations in respiration vary according to the level of the lesion. Thus, a cord injury at or above the level of the fourth cervical is immediately fatal through paralysis of the diaphragm, which muscle receives its main innervation from the fourth segment. In injuries in the cervico-dorsal and dorsal regions all the intercostals below the level of the lesion are paralysed, with consequent and proportionate diminution of thoracic respiration. In the higher of such lesions the forced muscles of inspiration will be called into play. Thus, there will still be some opening of the upper part of the thorax through the utilisation of the scalenes, sterno-mastoid, etc. In most of these cases, however, respiration is carried out mainly by exaggerated use of the diaphragm, the abdomen bulging outwards as the diaphragm contracts and falling back, during expiration, in a jerking or flopping manner. The lungs, imperfectly aerated, soon become water-logged. The patient experiences an ever-increasing difficulty in coughing and expectorating his mucus and is finally "drowned in his own mucus." Hypostatic pneumonia is always to be feared.

The *temperature* affords a valuable guide to the progress of the case, being high in the more serious cases, with hyperpyrexia towards the end.

**Special symptoms observed according to the level of the transverse lesion.—First four segments.**—Death is almost instantaneous through paralysis of the diaphragm.

**Between fifth cervical and first dorsal.**—*Motor symptoms* vary. When

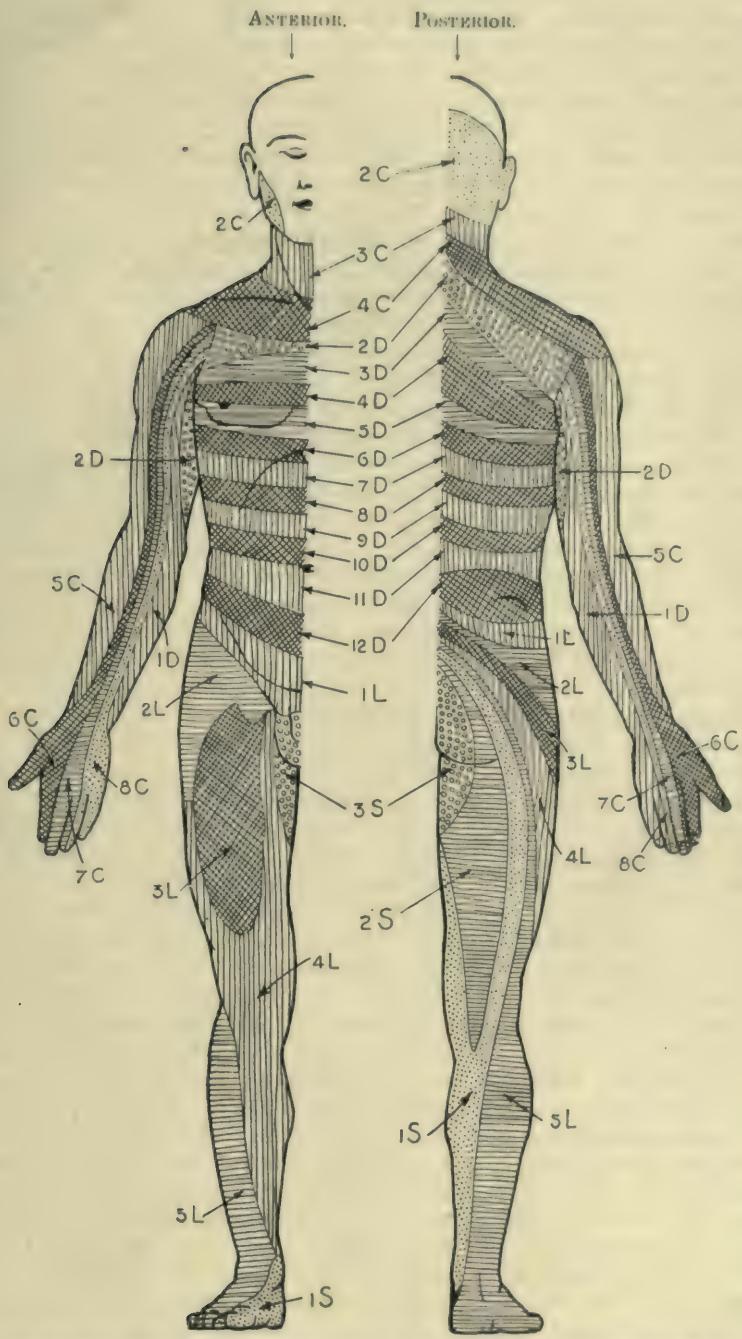



FIG. 266.—Diagrammatic representation of the segmental distribution of the spinal nerves. C, D, L and S represent the cervical, dorsal, lumbar, and sacral nerves respectively.

the *fifth* segment is involved, there is paralysis of all four limbs. When confined to the *sixth* segment, the fifth nerve is irritated by blood effusion and the patient lies in a characteristic attitude, " upper arm abducted and rotated out, elbow flexed, hand supinated and flexed, and retention of sensation along the radial side of the limb." In lesions involving the *seventh* segment a somewhat similar but less distinctive position is assumed. When confined to the *eighth and first dorsal*, the patient again may lie in a typical position, " slight abduction at the shoulder and flexion at the elbow; forearm semipronated and lying on the abdomen, with slight flexion of the fingers and anæsthesia along the ulnar side of the forearm and hand."

*Sensory disturbances.*—The upper limit of anæsthesia seldom extends higher than the second interspace, the region above being supplied by branches of the superficial cervical plexus (supraclavicular, suprasternal, and supra-acromial—second, third and fourth cervical).

*Involvement of cervical sympathetic.*—The pupil-dilator fibres, arising in the neighbourhood of the third nerve nucleus, pass down the lateral columns of the cord to emerge by the first and second dorsal roots, thence joining the inferior cervical ganglion of the sympathetic and so passing up to their distribution in the eye. Paralysis of these and other fibres of the sympathetic leads to contraction of the pupils, narrowing of the palpebral fissure, and slight recession of the eyeballs.

*Respiration* is purely diaphragmatic, and hiccough may be distressing.

The *pulse* may be low, 40 to 50 to the minute. This slowing is dependent on paralysis of the cardio-accelerator fibres, which pursue a similar course to the pupil-dilator fibres in the cord but emerge lower down—fourth to ninth dorsal.

**Second to eleventh dorsal inclusive.**—Motor paralysis and anæsthesia are co-extensive. The abdominal muscles are paralysed, and the intercostals below the level of the lesion.

**Dorsi-lumbar region.**—All the spinal segments representing the lumbar, sacral and coccygeal nerves lie between the levels of the eleventh dorsal and first lumbar vertebræ. In consequence, a lesion in the dorsi-lumbar region will lead to complete paralysis, anæsthesia, etc., in the regions supplied by those nerve trunks. In general, the patient suffers from anæsthesia from about the region of the umbilicus downwards, paralysis of both lower extremities, and paralysis of the sphincters of micturition and defæcation. Abdominal distension, however, is less marked than in the higher injuries, and respiration, both intercostal and diaphragmatic, is practically unimpaired.

It should be noted that a very large proportion of all fractures of the spine occur at about the level of the tenth dorsal vertebra.

**Conus medullaris.**—Injuries involving this part of the cord affect the third and fourth sacral nerves. In consequence, there is present a saddle-shaped area of anæsthesia over the buttocks and back of the thighs, as also over the perineum, scrotum and penis. The urethra is insensitive, and the rectal and vesical sphincters are paralysed. There is no anal reflex, and the levatores ani are also involved. The testes retain their sensation. Lesions of this nature are said to follow most frequently after heavy falls on to the buttocks. They are of rare occurrence.

**Cauda equina.**—The nerves of the cauda equina, being situated in a comparatively roomy canal, are seldom injured in such a way as to lead to complete paralysis. Both paralysis and anæsthesia vary according to the level and completeness of the injury. As a rule all the muscles of the thighs are

paralysed except those supplied by the anterior crural, obturator and superior gluteal nerves. The perineal and penile muscles are usually included in the paralysis. There is anæsthesia of penis, scrotum, lower half of buttocks and the entire lower extremity with the exception of the front and outer side of the thigh. In any case, there is in all probability an incompleteness in the symptoms, irregularity in the palsy, and asymmetry in the anæsthesia. Neuralgic pains along the course of the lumbar and sacral nerves compressed are common. The knee-jerk is not necessarily lost if the injury is situated below the fourth lumbar.

(B) **Symptoms resulting from a partial lesion of the cord (lateral crushing, pressure exercised by depressed bone, blood-clot, etc.).**—Though the symptoms as given below represent the clinical conditions observed in a case of partial cord lesion, it must be clearly understood that these typical symptoms are not seen in the early stages of the case. All partial lesions are associated for the time being with such *concussion* of the cord (see below) that the primary symptoms are practically identical for the time being with those observed in complete crushing of the cord. It is only when some symptoms clear up that a diagnosis of partial injury can be made with any degree of certainty. Further allusion will be made to the differential diagnosis.

*Motor symptoms.*—These predominate over the sensory disturbances, the paralysis being complete in those parts directly supplied by the region of cord crushed or compressed, with a tendency for this paralysis to be one-sided, or at least unequally distributed. The distal parts suffer more than the proximal, and the extensors more than the flexors. Thus, the patient may be unable to lift up the foot and yet capable of flexing his toes. The paralysis also may deepen in character or fluctuate from day to day, improving or getting worse, according as recovery takes place or myelitis and œdema develop. In addition, *irritative* phenomena accompany the paralysis, with painful cramps and twitchings in neighbouring groups of muscles. Contractures, too, are often seen, due to the excess of flexor over extensor tone.

The *deep reflexes* (*e.g.*, knee-jerk), though primarily abolished, may return later, then perhaps becoming exaggerated, with the still later appearance of a well-marked Babinski's sign (extensor plantar-response).

*Sensory* disturbances may be absent. When present they are incomplete and often "irritative" in type—painful neuralgias, formications, and increased sensations of heat, pain, etc. Any area of anæsthesia will in any case be incomplete, and will not reach such a high level as that attained by the co-existent motor symptoms. Sometimes there is hyperæsthesia on the one side and anæsthesia on the other.

*The bladder and rectum.*—The fibres on the sound side of the cord may suffice to maintain a modified degree of micturition and defæcation power. Thus, the patient may be aware of a desire for micturition; he may also be capable of appreciating in part the act of catheterisation. He, however, is seldom capable of freely and completely emptying his bladder.

**Concussion of the cord.**—In addition to the anatomical lesions of the cord, complete and partial crushing, there is a third factor requiring consideration—*concussion* of the cord, a condition often regarded as of physiological interest only. All available evidence, however, tends to prove that concussion of the cord is a very definite entity, closely resembling in its pathology concussion of the brain. In many cases there is quite definite evidence of cord injury, bruising, minute hæmorrhages in the substance of the cord, and blood-stained fluid in the membranous spaces; but in some there are

no visible lesions with the exception of some venous engorgement and œdema. In the latter it is highly probable that the injury has resulted in a more or less localised arterial anæmia, due to vaso-motor paralysis, with secondary venous congestion and spinal œdema. The œdema is recognised by the increase of fluid in the membranous spaces and by the water-logged appearance of the cord itself. In fact, in almost every detail, both pathological and symptomatic, cerebral concussion and spinal concussion are analogous.

In any case, it is quite clear that concussion of the cord may lead to an immediate suspension of all its functions, thus producing for the time being a condition identical with that seen after a complete transverse lesion. The differential diagnosis between the two conditions is rendered more difficult by a third factor, for it has already been stated that a partial lesion of the cord is, in its early stages, associated with concussion, and is practically identical in its symptomatology with that resulting from a complete lesion.

It is necessary, therefore, to allude to some of the more important points which assist in the *differential diagnosis* between a complete transverse lesion of the cord, a partial lesion with concussion, and pure concussion.

In attempting to arrive at a decision it may be stated at once that it is often quite impossible to ascertain the exact condition of affairs till time has elapsed. This may be a question of days. There is, however, one important point in the *diagnosis of concussion* as distinct from the other two conditions, a feature that is said to be invariably present. All motor conduction may be abolished, the patient being completely paralysed below the level of the lesion, but he is capable of *appreciating most sensations ;* sensation is impaired, but is existent. After the lapse of a day or two, perhaps longer, the functions of the cord will gradually be restored, first to full sensation and then to full motor power. The extent of actual recovery of function depends on the degree of bruising of the cord, if any, and on the care with which the patient is treated. For further points in connexion with this question, see *Railway-spine* (p. 633).

A partial lesion may be diagnosed with reasonable certainty if there is *any motor power* retained below the level of the lesion, if there is any appreciation of sensation, whether of touch, of heat and cold, or of pain, if the patient is capable of appreciating the *fulness of his bladder* or the act of *micturition and catheterisation*, and if he is capable of forming some idea as to the *position of his limbs.*

*Further evidence as to recovery of cord function.*—Whether the lesion is incomplete or the case one of concussion, the first signs of functional recovery are shown by the return of reflexes (especially the knee-jerk), the return of sensation and the recovery of motor power, in that order. When sensation returns, touch is first appreciated, then the sensation of pain, and finally that of heat and cold. The lower segments invariably recover before the upper. Also, with respect to motor recovery, the flexors regain their function before the extensors, the distal segments again before the proximal. Thus the patient will first show that he is able to flex his toes. Another important sign of functional recovery consists in the appreciation by the patient of the condition of his bladder and bowels, the act of catheterisation, etc.

All these earlier signs may progress until the patient is completely cured—a rare event. They may stop short at any period, and relapses may take place, due to the advent of myelitis, spreading œdema, spinal meningitis, etc.

*Prognosis of fracture-dislocation.*—The prognosis of fracture-dislocation of the vertebral column may be estimated by reference to the following table, a series of 244 cases collected by Burrell :—

| | | | | | |
|---|---|---|---|---|---|
| Fracture in the cervical region . | . | 33 per cent. cases. | Mortality, | 85 per cent. |
| ,, ,, upper dorsal region | . | 16 ,, ,, | ,, | 76 ,, |
| ,, ,, lower dorsal region | . | 32 ,, ,, | ,, | 56 ,, |
| ,, ,, lumbar region . | . | 16 ,, ,, | ,, | 50 ,, |

Of the cases that recovered, 62 per cent. were capable of doing some work and 38 per cent. were bedridden, hopeless cripples.

These statistics confirm the statement previously made that the cord suffers serious injury in the great majority of cases of fracture and fracture-dislocation of the vertebral column.

Death, when occurring early, is usually the result of respiratory complications, breathing becoming more and more difficult owing to the impossibility of clearing the lungs of the collecting mucus. Hypostatic pneumonia is of frequent occurrence. When the patient recovers from the immediate accident, the main dangers to be feared are infections of the genito-urinary tract, myelitis, toxæmia from bedsores, and exhaustion.

*Treatment.*—It is essential that all *movements* to which the patient is subjected, both for examination and for treatment, are conducted with the greatest care. He should be rolled from side to side—never lifted up by the head and shoulders. A water-bed should be used from the first, the patient being placed flat on his back, with supports to the head and neck in the event of a high injury. The *bladder* demands special attention, and the patient should be examined frequently in order to determine whether he suffers from true incontinence or from retention with overflow. In the former instance, a bottle is placed between his legs with the penis inserted therein. If he has retention with overflow, serious damage will occur to the bladder wall in the event of neglect.

Cystitis is the great danger in spinal injuries, but there is, unfortunately, considerable doubt as to the course which it is advisable to adopt. Formerly the rule was to catheterise the patient twice or three times in the twenty-four hours, taking every precaution to avoid infection. Cystitis, however, almost invariably develops, whatever precautions are taken. To avoid this serious complication, it was suggested that a suprapubic cystotomy might improve matters, the bladder being drained continuously. This method, however, seems to have been followed by no better results. More recently, insomuch as the sphincter of the bladder is markedly weakened, the method of "expression" of urine has been tried. The bladder is compressed above the pubes two or three times a day, and the greater part of the urine expressed. Even after this cystitis seems almost as likely to develop as after catheterisation, etc. This "expression" method, however, is fairly satisfactory and should be adopted. Failing a good result, regular catheterisation of the bladder should be carried out.

The *skin* of the patient, more especially where it is subject to pressure, is washed daily, cleansed and dried with spirit, and then dusted with boracic and starch powder. All bony prominences are protected by special air and water cushions. In the event of the development of *pressure-sores* they must be treated vigorously (thorough cleansing with antiseptic lotions and the application of dry dressings) and protected from pressure. These sores are trophic in origin, and when infected may spread with great rapidity, both in area and in depth.

In the less serious cases, *nourishment* is administered in the ordinary way; in the more serious, by feeding-bottle or nasal tube.

Strong *purgatives* are required. Their action, when once started, will demand on the part of the nurse continuous attention until the bowels have been thoroughly emptied.

Oxygen is useful to assist in the aeration of the blood, and pituitary extract and similar preparations in maintaining blood-pressure. Morphia will be demanded, in view of the intense neuralgic pains in the course and distribution of the nerve trunks compressed in the region of the intervertebral foramina, etc.

*Question of operation.*—The question of operation is always a difficult one. The following facts, however, must be taken into full consideration :—

1. The spinal cord, if crushed, is damaged at the moment of the accident and damaged beyond the hope of repair by surgical intervention.

2. The cord, even if cleanly divided and brought together by suture, is incapable of regeneration. It is true that two or three remarkable cases have been reported, but all experimental evidence obtained by sections of the cord in lower animals proves conclusively that there cannot be any true regeneration of nerve fibres from one end of the severed cord to the other. This is largely due to the absence of a neurilemma sheath in cord fibres, a structure regarded as of considerable importance for nerve regeneration.

3. The results obtained by operation (laminectomy) for crushed cords are most unsatisfactory.

Consequently, when a diagnosis of crushed cord can be made with tolerable certainty, laminectomy is not likely to be of the slightest value.

When the symptoms point to the probability of a partial lesion, either in the very early history of the case or after some few days, laminectomy holds a much stronger position. The prognosis is not favourable, but many good results have been obtained by operation. Operative treatment has gained its greatest success in such cases as improve up to a certain stage and then "mark time" or retrogress. Laminectomy, in such cases, has not infrequently enabled the surgeon to remove depressed bone or evacuate blood-clot, and thus improve or cure the conditions.

In general, however, it may be stated that the history of laminectomy for injury of the cord is a very gloomy one.

*Localisation of the lesion.*—Previous to carrying out any operation it is absolutely essential that the level of the lesion should be accurately determined. This is done (1) by X-ray examination, and (2) by careful estimation of the significance of the upper limits of anæsthesia and paralysis. The oblique direction of the spinous processes in the dorsal region and the obliquity of the spinal nerves within the spinal canal must both be taken into full consideration. In addition, operative experience has shown again and again that the exposure has been carried out too low. In brief, it may be accepted that the centre of the incision should be situated over the tip of the spinous process of a vertebra which is placed two or three higher up the series than that vertebra which is thought to correspond to the level of the lesion. Thus, if the upper limit of anæsthesia corresponds to the tenth dorsal vertebra, the centre of the incision should be placed over the spine of the seventh or eighth dorsal vertebra.

**Laminectomy.**—With the patient in the semi-prone position an incision is made in the middle line over the spines. The muscles are peeled away on either side and retracted so as to expose the laminæ in their whole extent.

Bleeding is arrested by hot water (110° to 115° F.) and by gauze plugging. The spinous processes of three or four vertebræ are then removed, flush with their bases, after which the saw is applied to the laminæ, close to the origin of the pedicles, not at right angles to the bone, but in a direction obliquely inwards. When a deep groove has been cut in all the laminæ, bone forceps are utilised to complete the division, each lamina being taken in turn. After this, the supra- and inter-spinous ligaments are divided below the lowermost of the laminæ and the rest of the laminæ removed *en masse*, from below upwards. This may expose an extradural blood-clot, but, in any case, it is necessary to open the theca, evacuating any blood collected there and relieving the intradural tension. The theca is then sewn up and the erector spinæ muscles approximated to one another with a few catgut sutures.

In the event of recovery the patient is kept flat on his back for some weeks, after which he may be allowed on a couch. The movements of the back, after a successful laminectomy, are surprisingly good.

**Pure dislocations of the vertebral column.**— Such injuries can, as previously stated, only occur in the cervical portion of the column, the almost horizontal arrangement of the articular processes allowing of such a lesion. The cord is obviously always liable to injury at the same time, but it may escape entirely, for the vertebral canal in this region is fairly capacious, larger than is required for the mere transmission of the spinal cord.

When the cord is injured, the symptoms are identical with those previously described under *Fracture-dislocation*, merely varying according to the level of the lesion.

When the cord escapes injury, the head is fixed in the position of torticollis, the chin pointing towards the opposite shoulder and the occiput drawn down towards the affected side. In addition, the patient suffers from severe neuralgia and muscular spasms along the course and distribution of the spinal nerves emerging in the vicinity of the dislocated articular processes.

From the point of view of *treatment* these cases are very difficult. It is obvious that forcible traction ought to be made to reduce the dislocation, but this method presents the great disadvantage that there is no inconsiderable risk that the cord may be injured in the process. In spite of this the attempt ought to be made.

**Railway-spine.**—In this condition the patient, as the result of an injury to the back, complains of weakness of the lower extremities, indefinite pains (often shifting in site), loss of sexual power, impairment of bladder function, of alterations in sensation, formication, tingling and burning sensations, and the like. Tactile and thermal changes may vary in position from day to day, and it is usually quite impossible to map out any area consistently insensitive.

Altogether, these symptoms of railway-spine suggest some lesion of the cord or spinal nerves, but they are far too indefinite to enable any early exact diagnosis to be formed. No doubt some of the patients are neurasthenic, others appreciate the pecuniary benefits which may be due, and unquestionably many have rapidly recovered if the remuneration has been sufficiently satisfactory. It has therefore been rather customary to look upon all cases of railway-spine as neuroses, as cases of traumatic neurasthenia, of humbug and the like. They are often lightly defined as cases of cord concussion, this condition being regarded as of little import. As previously stated, however, there is every reason to believe that such a view is incorrect. The experiments of Newton, and a comparison between cerebral and spinal concussion, both from the symptomatic and pathological points of view, tend to

show that "there is an organic basis for the signs and symptoms of railway-spine and allied conditions of traumatic neurasthenia."

In any case, the greatest circumspection is required in estimating the case at its true value. The following types require investigation :—

1. A neurotic patient, or one financially interested, who receives a blow in the back and who knows, or reads up, something about "back injuries."

2. A similar type of patient who is in reality suffering from the after-effects of spinal concussion.

3. An otherwise normal patient who is suffering from a mild form of spinal concussion.

4. A case of well-defined spinal concussion without real injury to cord and membranes.

5. A case of well-defined spinal concussion with some injury to the cord and hæmorrhage in the membranous spaces.

It is obvious that the diagnosis between these varying conditions is not too easy. Frequent examinations are required, and special attention must be paid to fluctuations in the areas of pain and sensory disturbances, daily variations in muscular weakness, control over micturition and defæcation, and the general progress of the case.

*Lumbar puncture* will be of assistance in showing excess of fluid in the subarachnoid space, with perhaps the admixture of blood.

In many cases any early diagnosis is impossible. Time and other considerations will assist in the classification of the case.

The *treatment*, in general, comprises rest, massage of muscles and treatment by electricity.

### Diseases of the Vertebral Column and Spinal Cord.

## Tumours of the Spinal Cord.

In their structure tumours of the cord show considerable variation. Sarcomata and gliomata are by far the commonest type; other varieties include endotheliomata, fibro-myxomata, tuberculomata, gummata, and cysts. The two first-named varieties, though malignant in the usual sense of the word, show a low grade of malignancy. They are seldom rapid in their rate of development, and they can be removed, in their earliest stages, with a reasonable hope of cure.

The spinal tumour may arise as an *intramedullary* growth, in the substance of the cord, or as an *extramedullary* neoplasm, either within or external to the dura mater. The actual site of origin is usually to be found in the posterior sensory roots, and even when arising in the cord itself the tumour is generally situated *posterior* to the cord. The dorsal region is the favourite site, next to which comes the cervical.

The tumours are found at all periods of life, though of most frequent occurrence in the young.

*Signs and symptoms.*—The capacious size of the vertebral canal, the primary small size of the tumour, its slow rate of growth, and the usual extramedullary posterior position of the growth all combine to bring about a slow and insidious development of symptoms in general. The signs and symptoms must be considered under two headings :—

1. *Root symptoms*, due to pressure on and irritation of the sensory and motor roots; and

2. *Cord symptoms*, due to pressure on and destruction of the tracts of the cord itself.

**Root symptoms.**—Owing to the usual development of the tumour in relation to the *posterior sensory roots*, the first symptom observed by the patient is paræsthesia—alterations in sensation, such as numbness, formication and similar alterations in sensibility. This stage is of short duration, and pain becomes the predominant feature. It is neuralgic in type, persistent and often agonising. It is referred to the distribution of the nerve roots irritated, though sometimes to more distant regions. Unilateral in the first instance, it soon tends to spread to the opposite side, such a change showing that the tumour is situated close to and has crossed the median posterior line of the cord. The pain is exaggerated on movement, so much so that the patient refuses to undertake such actions as will produce it.

The pain tends to increase in severity and soon becomes associated with hyperæsthesia. Still later, when the nerve roots first affected become degenerate, the painful area will become numbed and finally anæsthetic. Absolute anæsthesia, however, in the course of a certain definite nerve trunk is seldom seen unless both the roots above and below are likewise involved. In other words, three roots must lose their conductivity previous to the development of absolute anæsthesia over the intermediate area. Again, when the area first affected does become anæsthetic, other neighbouring roots will have become involved and will pass through the same stages.

*Motor root symptoms* develop in direct proportion to the pressure exercised by the tumour on the anterior roots. They are seldom very conspicuous. When present, they consist of painful spasms in the muscles supplied by the root, with the later development of spasticity and exaggeration of reflexes. Still later, if the nerve undergoes pressure degeneration, the muscles will become paralysed and undergo atrophy, whilst the reflexes will be abolished. It is probable, however, that complete degeneration will not occur in a muscle unless the roots above and below are likewise involved. Few muscles are supplied by one segment only.

It will be observed, in both sensory and motor root changes, that the order of events is—(1) irritation, and (2) loss of conductivity of the root or roots involved.

**Cord symptoms.**—Unless the tumour is intramedullary in position, the symptoms due to actual pressure exerted on the cord may be postponed for some time. Still, whether the tumour be situated within or outside the substance of the cord, the common posterior position of the growth again leads to the preponderance of sensory symptoms. The cord symptoms, however, require to be divided into two groups—(1) *direct spinal symptoms*, due to compression or destruction of the spinal centres of the particular part of the cord involved; and (2) *indirect spinal symptoms*, due to compression of the long tracts of the cord.

*Direct spinal symptoms.*—These are both motor and sensory. The sensory consist of girdle-pains, neuralgic pains and hyperæsthesia, followed by numbness and anæsthesia. The motor symptoms comprise painful cramps and spasticity, followed by paralysis and muscular atrophy. In both cases the changes take place in the parts *directly* supplied by that part of the cord which is actually compressed by the tumour.

*Indirect spinal symptoms.*—A tumour that is laterally situated will, by its compression of the cord, bring about typical, or modified, Brown-Séquard phenomena. That is to say, there will be spasticity and then complete paralysis, with atrophy of muscle fibres and loss of muscle sense, of all muscles below the level of, and on the *same* side as, the lesion itself. As

regards sensation, there will be some loss of tactile sensibility, together with diminution in the appreciation of heat, cold, and pain on the side *opposite* to that on which the growth is situated.

When the muscles are spastic the reflexes are exaggerated, when paralysed they are absent.

These unilateral motor and sensory changes soon become bilateral, in direct proportion to the position of the tumour, its rate of growth, and the degree of associated œdema and hæmorrhage. Finally, the body becomes completely paraplegic from the level of the lesion downwards, with corresponding loss of reflexes and paralysis of the sphincters of both rectum and bladder.

In brief, therefore, a tumour pressing *laterally* on the cord will bring about motor changes and loss of muscle sense on the *same* side as the tumour, with diminution or loss of tactile and other similar sensibilities on the *opposite* side. This picture, however, soon changes to that of complete paraplegia.

*Prognosis.*—Unless the tumour is completely and successfully removed the chance of recovery is well-nigh hopeless. The progress of the case may be very slow, but cord symptoms are certain to develop sooner or later, followed by bedsores, infection of the genito-urinary tract, etc. Sarcomata and gliomata can only be removed in their earliest stages with any hope of non-recurrence. On the other hand, the endotheliomata, gummata and fibromata are far more amenable to surgical treatment.

*Treatment.*—It is absolutely essential that the level of the tumour should be determined with accuracy. For this purpose the band of hyperæsthesia or the upper level of the painful area should be taken as a guide. In any case, it must be remembered that the *lowest* level of the tumour corresponds to the *highest* level of the sensory disturbance.

Thus, if the hyperæsthetic band corresponds to the course and distribution of the tenth dorsal nerve, it is highly probable that the tumour is situated at or immediately above that particular dorsal segment.

In the operation of laminectomy for exposure of the tumour, it is necessary to have a clear indication on the surface of the body of the cord segment involved. With this object in view it is necessary to bear in mind the relation of the spinous processes, as felt in the median posterior line, to the segments of the cord. The cord terminates at the lower border of the first lumbar vertebra. In the upper cervical region the spines are more or less on a level with their corresponding cord segments, but in the lower cervical and throughout the dorsal region the spines, by reason of their obliquity, are situated much lower than their corresponding segments. In the upper dorsal region two must be added to the number of the vertebræ, and in the lower dorsal region three, to give the corresponding segment of the cord. Thus, opposite the fifth and ninth dorsal spines are situated the seventh and twelfth spinal segments. Putting this in a more practical way, if the hyperæsthetic area indicates that the tumour is related to the seventh or twelfth spinal segment the centre of the incision must be situated over the spine of the fifth or ninth dorsal vertebra respectively. The lower part of the eleventh dorsal spine and the region immediately below it are opposite the lower three lumbar segments. The twelfth dorsal spine and the region immediately below are opposite the sacral segments. Another point in the localisation of the tumour is tenderness immediately over, or to one side of, the spinous processes. When present, this symptom is said to be of the greatest value.

**Laminectomy.**—The main essentials of laminectomy have been described on p. 632, and it merely remains to add that, although the theca must be

opened as a first stage, it may be inadvisable to remove the tumour at the time. If readily removable, the tumour should be shelled out, but if intramedullary in position it is recommended that a vertical incision should be made in the median posterior line of the cord down to the tumour. After this the muscles are approximated and the wound sewn up. In the course of about ten days the wound is reopened, and it may be found that the tumour has extruded itself from the cord, following the line of least resistance, either in whole or in part. By this means less damage is done to the surrounding cord than would have been the case if it had been shelled out in the first instance. The theca is sewn up and the muscles approximated from side to side. Great care must be taken in the closure of the wound. It is essential that there should be no leakage of cerebro-spinal fluid.

## New Growths of the Spine.

**Sarcoma** of the spine is rare, secondary carcinoma somewhat less rare. Both are liable to confusion with spinal caries.

Malignant disease of the spine may attack persons of any age, but, as secondary carcinoma is more frequent in people of advanced life and caries less common in them than in the young, it is specially in older patients that a new growth of the spine may be suspected. The symptoms are very much like those of Pott's disease, but the pain is usually particularly severe. As is the case in Pott's disease, it is referred along the spinal nerves. Paraplegia is frequent, and early in onset. Occasionally the new growth invades the structures around the spine and extends in exactly the way that an abscess does, so that a mass invading the psoas may be mistaken for a psoas abscess. The curve produced in the spine may be like that of caries; it is often, however, rounded rather than angular. The discovery of the primary growth will of course assist the diagnosis in the secondary cases.

Sarcoma may be of the round, spindle-celled or mixed type; it usually remains soft, and does not ossify as sarcomata of bone so often do. Carcinoma is most frequently secondary to a primary growth in the breast, less often to an intestinal growth. Colloid carcinoma appears to have a special tendency to affect the spine. Melanotic sarcoma when it occurs commonly gives rise to nodules in the vertebræ; these, however, are of purely pathological interest.

Treatment of new growths of the spine must be palliative only. The spine should be protected from movement and anything possible done to relieve the patient's pain.

## Spina Bifida.

The various grades of spina bifida all result from a primary or congenital defect in the development of the central neural canal and its investing membranes and vertebræ. The earliest sign indicative of the formation of the spinal cord consists in a groove in the surface epiblast in the median posterior line of the body (the *neural or medullary groove*). The lateral margins of this groove become somewhat upraised (*the medullary folds*); these folds coalesce with one another, with the final formation of an epiblastic tube (the *neural or medullary canal*). The walls thicken into the substance and structure of the cord proper, the canal remaining as the central canal of the cord. The tube gradually sinks into the underlying mesoblast and is eventually completely cut off from the surface epiblast by the overgrowth of

the enveloping mesoblast. That part of the mesoblast which comes into direct contact with the cord becomes differentiated into the membranes of the cord, the more distal portion forming a basis in which the vertebræ are developed, the bodies in front, the pedicles and laminæ on either side. The laminæ unite together to form the spinous processes. By the fusion of the laminæ the cord is finally cut off from the surface and protected on all sides. The enclosure of the neural tube is now complete. By defects in this process of development the various grades of spina bifida arise.

*Varieties of spina bifida*, in order from the most serious to the least :— Myelocele, syringo-myelocele, meningo-myelocele, meningocele, spina bifida occulta. When all the varieties are taken together, spina bifida is still a comparatively rare disease. In some cases the cord and vertebral canal are ill-

Fig. 267.—A case of spinal meningocele.

formed throughout their whole extent, and in others the upper cervical region is the part implicated. The lumbo-sacral region, however, is the part involved in the great majority of cases. It is rare for the child to be devoid of other deformities. Amongst the more common associated defects are hydrocephalus, microcephalus, talipes, webbed fingers, hare-lip and cleft palate.

In **myelocele** the neural tube remains visible on the surface of the body, either as a tube proper or as a canal with upraised margins. In the former case the medullary folds unite with one another to form a tube, the process of development stopping short at that stage, whilst in the latter instance the medullary folds fail even to coalesce, the cord presenting in a very elementary condition. The failure of the cord to sink into the underlying mesoblast allows of it being visible on the surface over a limited area of the back, more commonly in the dorsi-lumbar region. In such a case the following conditions will be observed :—The section of cord involved appears on the surface as a blue-black or reddish structure, covered in part by dried secretion,

obscured by tissue representative of the membranes, or soaked in more or less purulent cerebro-spinal fluid. On either side stunted and deformed laminæ may be felt embedded in the spinal muscles. The opening is oval in shape, tailing off above and below into normal tissues.

In most cases the child is born dead. Those that survive birth are almost invariably paralysed below the level of the lesion and die within a few days.

In **syringo-myelocele** the medullary folds coalesce to form a tube, and the tube may sink to such a degree into the underlying mesoblast as to be cut off from the surface epiblast. In any case, whether the tube is cut off from, or adherent to, the skin, the laminæ which should enclose it are either completely wanting or totally insufficient for the purpose. In consequence, there is in the median posterior line a swelling containing the cord, and, in addition, for reasons not easily explained, there is a dilatation of the central neural canal, the cord being distended and the wall of the canal thinned.

From a *clinical* aspect a syringo-myelocele is represented by a protrusion in the median posterior line, more commonly in the lower dorsal region. The tumour is moderately soft, swells up when the child cries and is partially reducible on the application of pressure. The overlying skin varies in character. It is sometimes quite healthy, at others thinned, translucent, perhaps even ulcerated, and discharging cerebro-spinal fluid. The cord itself occupies the cavity of the sac, and, whether the central canal is dilated or not, cord symptoms are almost invariably present, paralysis of the lower extremities, incontinence of urine, etc.

In **meningo-myelocele,** perhaps the commonest type of spina bifida, the neural canal again is incompletely cut off from the surface epiblast, and the laminæ are stunted and everted. The deformity, however, occurs most commonly in the lumbo-sacral region, and the membranous sac contains the cords of the cauda equina instead of the cord itself, as in the previous case. These cords enter the sac at its upper opening, traverse the sac and re-enter the vertebral canal at the lower end. One or more cords may actually be attached to the skin, leading to some degree of "umbilication" of the sac wall, this appearing externally as a dimple in the skin. The integumental covering is usually thinned and translucent at the apex of the tumour, more or less normal at the periphery.

The sac varies in tenseness according to the contents and the amount of contained cerebro-spinal fluid, swelling up when the child strains and somewhat reducible on pressure. On transillumination of the sac, nerve strands or fibrous bands are clearly visible. The inclusion of the cords of the cauda equina, by a process of irritation, leads to contracture and rigidity of the lower extremities, with increase of knee-jerk and well-marked Babinski's sign. Sometimes actual paralysis of the lower extremities is seen, of a flaccid type, with absence of reflexes. This latter condition is accompanied by incontinence of urine and fæces.

In **meningocele,** a common variety of spina bifida, the hernial sac, consisting of more or less altered membranes, protrudes in the median posterior line, more especially in the lumbo-sacral region. The sac is tense or flaccid according to the amount of contained cerebro-spinal fluid. It contains this fluid, nothing more. The cords of the cauda equina are directed downwards more or less vertically from the upper communication with the vertebral canal to the lower. The number of vertebræ included in the deformity is subject to considerable variation. Sometimes the abnormality extends throughout the greater part of the spine; in some few cases one vertebra alone is involved, but in the great majority the deformity includes three or four vertebræ. The

size of the communication between the cavity of the sac and the canal proper varies in direct proportion.

On transillumination it will be seen that the sac is translucent throughout. The overlying integument is often normal, more especially in the less extensive cases. In other instances it is thinned and ulcerated at the apical part of the tumour, perhaps discharging cerebro-spinal fluid.

Inasmuch as the sac contains neither cord nor cords of cauda equina,

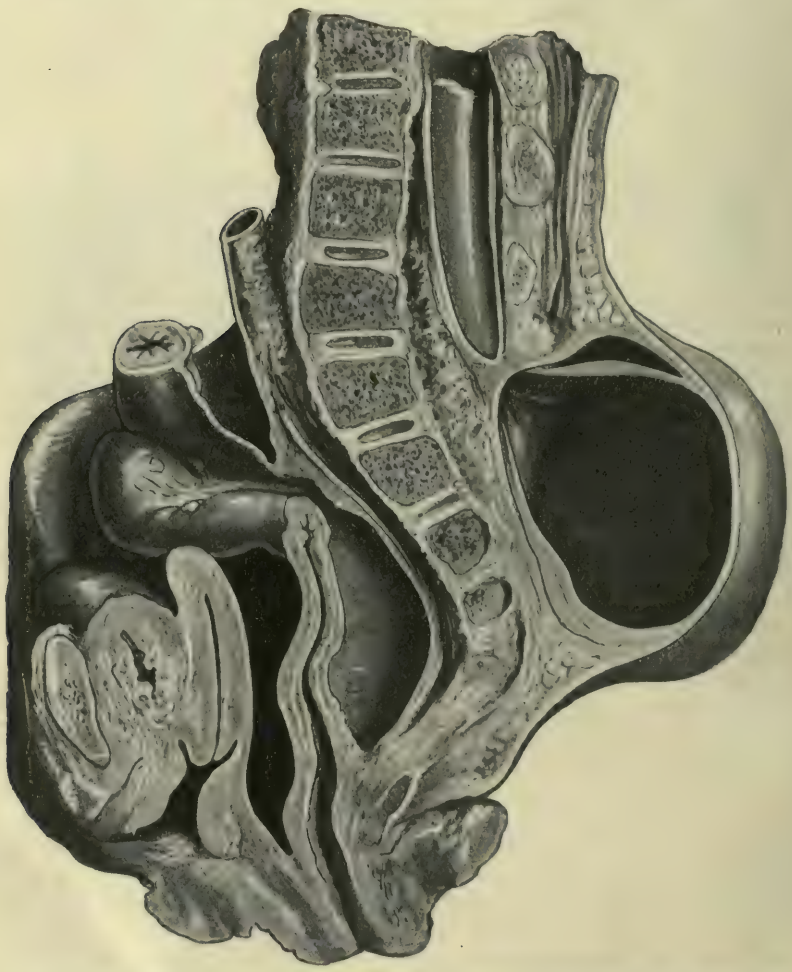


FIG. 268.—A case of spinal meningocele. (St. Bartholomew's Hospital Museum.)

symptoms referable to cord involvement may be entirely absent. Occasionally there is some spasticity of the lower extremities and weakness of the bladder, in which case it is presumed that some cords are included in the neck of the membranous protrusion.

In **spina bifida occulta** the only outward evidence of any spinal deficiency is a tuft of hair, a dimple in the skin, a lipoma, a nævus, or a primitive "tail" in the middle line of the lumbo-sacral region. On X-ray examination, however, it may become evident that there is some deformity

or deficiency in the formation of one or two vertebræ. In all other respects there is no evidence of spinal deformity.

**Points in the differential diagnosis of the various grades of spina bifida.**—Both myelocele and spina bifida occulta present no difficulties in diagnosis; the conditions are apparent. In the other three varieties there are certain features in common—a hernial protrusion, a median gap between the laminæ, and a thin, often ulcerated, covering. It is not always easy to determine which particular variety is present, but the following points will be of assistance:—

*The position of the tumour.*—Syringo-myeloceles in the cervical and dorsal regions.

Meningo-myeloceles and meningoceles in the lumbo-sacral region.

*Translucency of the tumour.*—Syringo-myeloceles either non-translucent or but slightly so.

Meningo-myeloceles translucent, but presenting shadows indicative of cords traversing the sac. Meningoceles translucent throughout.

*Cord symptoms.*—Almost invariably present in the case of syringo-myeloceles, probably flaccid paralysis of the lower extremities.

Usually present in meningo-myeloceles, probably spastic paralysis of the lower extremities.

Usually absent in meningoceles.

In general the statement is correct that "the greater the tendency to cord involvement the more likely is it to be a case of syringo-myelocele."

*Prognosis.*—Myeloceles are inevitably fatal, and spina bifida occulta is rather in the nature of a surgical curiosity than otherwise, requiring no treatment other than the possible removal of the "tail," lipoma, etc. In the other three varieties a spontaneous cure is barely within the bounds of possibility except in the mildest type of meningocele, where the protrusion may have the narrowest possible channel of communication with the thecal space. In the great majority of cases the condition tends to become worse, the overlying integument ulcerating, perhaps bursting, with the consequent development of spinal meningitis. Infection of the meninges and cord is the usual result—the cause of death. Still, in spite of this fact, some few cases of spina bifida have lived to a good age.

*Treatment.*—Myeloceles, syringo-myeloceles, most cases of meningo-myelocele, and those cases of meningocele which are associated with hydrocephalus are beyond the reach of surgical treatment. Even in meningoceles it is desirable to have a mild type of case, one in which the osseous deformity is inconsiderable, the integument in a fair condition, and the patient otherwise healthy.

When radical treatment is contra-indicated every attention must be paid to keep the skin clean, and to avoid contamination from urine and fæces. In addition, to prevent pressure effects, the tumour may be protected with a metal or celluloid cap, fastened round the body. When especially unhealthy, fomentations may be applied, but it is better to keep the parts dry, dusted with borax and starch powder and covered with dry gauze.

When the tumour is tense fluid may be withdrawn by aspiration, with the twofold object of preventing the cyst from bursting and at the same time of relieving the tension on the skin and so aiding in its repair. A fine needle is introduced through the skin some little distance away from the margin of the tumour, passed beneath the integument and into the sac cavity, fluid being withdrawn in such a quantity as will render the cyst flaccid. Pressure may then be applied with a Martin's bandage in the hope of preventing

the reaccumulation of fluid. It must be acknowledged that a successful result is seldom obtained. Formerly it was advised that Morton's fluid should be injected into the sac. This treatment is not regarded with favour.

When the case appears suitable for operation some days should be spent in rendering the local conditions as favourable as possible. The skin over and around the tumour is painted with a 1 per cent. solution of iodine in spirit, after which an elliptical skin incision is made, sufficient tissue being left to allow of its being brought together at the end of the operation. The sac is dissected off from the surrounding parts and ligatured at its neck or so cut away as to allow of approximation of lateral flaps. If the sac is supposed to contain any cords it should be slit up and the contents examined. It may perhaps be feasible to replace such cords in their normal position, then to dissect away the sac and form a new membranous roof to the spinal cord. Such bands as are attached to the membranes may be cut away, for, whatever their original function, it is obvious that they can be of no importance when having such connexions.

Many methods have been tried to make good the absent laminæ. It is best to rest content with bringing across from either side a flap of erector spinæ muscle, sewing them together in the middle line. The skin is sewn up with care and the wound protected with collodion gauze and dressings.

## Sacro-coccygeal Tumours.

The term "*sacro-coccygeal tumour*" has been applied to all congenital tumours arising in that region of the body. In nature, however, they are diverse, and their mode of development is not always clear. Some are definitely dermoid in nature, that is to say, they result from a faulty coalescence of the cutaneous covering of the body in the median posterior line. The mildest type of such deformity is represented by the *post-anal dimple*, a small depression in the sacro-coccygeal region. This depression may be the orifice of an actual sinus, the *coccygeal sinus*, and finally a complete *dermoid* may be seen, often of considerable size. This cyst will be unconnected with the overlying skin, lined with squamous epithelium and filled with the usual sebaceous material, hair, etc. It is usually unattached to the underlying bone, but often lies in a depression, this being brought about by the pressure of the tumour and by arrested development in the bone. These sacro-coccygeal dermoids may be mistaken for meningoceles, though their want of translucency, their sacro-coccygeal position, and the healthiness of the overlying skin should prevent any error of diagnosis. In addition, an X-ray examination will show that there is no absolute deficiency in the formation of the sacrum and coccyx.

Dermoids should be removed whenever the conditions are favourable. Coccygeal sinuses should be slit up, the lining walls dissected away, the cavity washed out with iodine solution, and the edges then united. In large septic wounds it may be desirable to plug lightly with gauze and allow of healing by granulation.

*Fatty* tumours of a congenital nature occur over the dorsal aspect of the sacro-coccygeal region, sometimes of considerable size. A *caudal appendage* may also be seen. These appendages do *not* possess elemental vertebræ. They may be cut away. Tumours of a *nævoid* or *lymphatic* (cystic hygroma) structure have also been observed.

The term "*sacro-coccygeal tumour*" has also been applied, and by some writers given solely, to tumours arising in front of the sacrum and coccyx,

and behind the rectum. Some of these are true *teratomata*, that is to say, they are "irregular conglomerate masses containing the tissues and fragments of viscera belonging to a suppressed fœtus attached to any otherwise normal individual" (Bland-Sutton). The majority of these tumours, however, develop in connexion with the post-anal gut and neurenteric canal. In the early embryonic condition the alimentary and spinal canals are connected with one another behind the caudal extremity of the notochord by a narrow canal, the *neurenteric canal*. Later on the proctodæum opens into the anterior part of the hind-gut, well above the level of the neurenteric canal, and subsequently the post-anal gut and the neurenteric canal normally undergo complete obliteration. Under abnormal circumstances, however, tumours may develop in connexion with the incompletely-obliterated structures.

All these tumours, whatever their origin, are constructed of, and contain, all the elements of the body, whether epiblastic, mesoblastic or hypoblastic. The tumours are often of considerable size. When possible they should be removed. The operation may be a formidable one.

## Lumbar Puncture.

### (A) As an Aid to Diagnosis.

*Quantity and pressure.*—Under normal conditions the fluid escapes under no great pressure. After a series of rapid drips, allowing of the collection of half a test tube full, the flow becomes slower and may soon cease. When under pressure and in excess the flow is more rapid, and two test tubes full or more may be collected in a few minutes.

Increased pressure does not necessarily imply a lesion of the central nervous system.

*Physical examination.*—Normal cerebro-spinal fluid is colourless, clear and slightly alkaline, with a specific gravity of about 1,005.

(*a*) In the event of hæmorrhage into the ventricles of the brain and into the dural and subarachnoid spaces of the brain and cord (whether from large hæmorrhages owing to rupture of blood-vessels, or from small hæmorrhages resulting from the diapedesis of red blood cells in inflammatory conditions), the fluid withdrawn is often intimately mixed with blood.

If the *hæmorrhage* is recent, the fluid will be of a red hue, and intact red blood cells will be found; if older, the fluid will be yellow and intact red cells absent.

(*b*) In some cases of *severe jaundice* the fluid is coloured yellow with bile pigment.

(*c*) In *inflammatory conditions* of the brain and cord the fluid is opalescent, turbid, flaky or purulent, or may clot, according to the nature or severity of the diease.

*Chemical examination.—Albumen.*—Normal fluid contains a small quantity of protein (about 0·01 per cent.). An increase occurs in all inflammatory conditions, but is less marked in the chronic than in the acute.

*Globulin.*—Normal fluid contains no globulin. Its presence is an important indication of a lesion of the central nervous system.

*Reduction of Fehling's Solution.*—A small amount of a reducing substance—not glucose—is present in normal fluid. It is usually diminished, and sometimes entirely absent, in tuberculous meningitis; it may be normal, increased or diminished in various forms of acute meningitis; and it may be increased in injuries to the brain and in diabetes, owing to the presence of true sugar.

*Urea.*—Normal fluid contains 0·02 per cent. to 0·05 per cent. of urea. Urea

is increased in certain kidney lesions, notably in advanced chronic parenchymatous nephritis, and is a sign of impending death when 0·30 per cent. is attained.

*Cytological examination.*—The normal cell count of the cerebro-spinal fluid is less than ten cells per c.mm. They consist of endothelial cells and lymphocytes.

A small increase (up to 100 per c.mm.), consisting chiefly of lymphocytes, is likely in syphilitic lesions and tumours of the brain or cord, abscesses of the brain, and encephalitis lethargica; a moderate increase (50 to 150) in tuberculous meningitis and poliomyelitis; a marked increase (150 to 2,000), consisting almost entirely of polymorphonuclear cells, is found in cerebro-spinal fever and the other forms of acute meningitis.

*Bacteriological examination.*—Under normal conditions the cerebro-spinal fluid is sterile. The following organisms may be found: *tubercle bacilli, meningococci, pneumococci, influenza bacilli, streptococci, staphylococci*, and less frequently other pyogenic organisms, also *trypanosomes*.

*Serological examination.*—The Wassermann reaction may be performed on the fluid. In syphilitic lesions of the central nervous system the reaction is often positive in the fluid when it is negative in the blood.

### (B) As an Aid to Treatment.

1. The evacuation of excess of cerebro-spinal fluid in hydrocephalus, tumour of the brain, cerebral œdema, cerebral hæmorrhage, injuries to the brain.
2. The introduction of sera: antitetanic, antimeningococcal, "salvarsanised" serum.
3. The introduction of drugs.
4. Spinal anæsthesia.

### Technique of Lumbar Puncture.

Required: sterilised lumbar puncture needle (Barker's) with sharp point; soap and water and ether; two or three sterilised test tubes with rubber bungs; syringe (10 c.c. Record with easy plunger) if sera are to be injected.

*Anæsthesia.*—The question of anæsthesia, whether local or general, must be decided on the merits of each case.

Generally it may be said that it is not required when the patient is unconscious, it is not necessary when the patient is quite master of himself, but it is advisable in nervous, restless, irritable and delirious patients.

*Position of the patient.*—Great care should be taken to get the patient into the proper position, as in this lies the secret of success in lumbar puncture.

The patient should be placed on his side at the edge of the bed, with his back towards the light. The back should be well arched by approximating the knees and the head. The arms should be by the side and slightly drawn forwards. The shoulder should be on the flat of the bed, and the head only should rest on the pillow. In this way the spines of the vertebræ are separated as much as possible, and the line of the spines is perfectly straight and horizontal.

*Cleansing the skin.*—The skin over the lumbar region should be well cleansed with soap and water, and ether or any other suitable antiseptic used.

*Selection of the point of puncture.*—The cord ends at the lower border of LI. or upper border of LII., and a point therefore below these vertebræ should, if possible, be chosen. The most suitable spaces are, in order, LIII., LII. and LIV.

If an imaginary line is drawn between the highest portions of the iliac crests, the first space between the spines above this line is the third lumbar space.

*Performing the puncture.*—The lumbar puncture needle should be held in the manner of a table knife and the skin punctured in the middle line in this space. When the skin is punctured the direction of the needle must be carefully attended to. It should point directly forwards and slightly upwards, so as to be parallel with the spines above and below it. The needle will pass through the supra- and inter-spinous ligaments, and after about 2½ inches (in an adult) have been introduced a sudden cessation of resistance will be felt as the dura mater is pierced and the point of the needle comes to lie within the theca.

If bone is encountered the needle should be withdrawn as far as the skin and the direction determined afresh.

On withdrawing the stilette the fluid should flow; if not, a flow may generally be induced by rotating the needle, slightly withdrawing it, or pushing it further in.

The fluid should not be allowed to flow too freely, as a sudden relative increase of the intracranial pressure over that in the spinal theca may force the medulla into the foramen magnum and give rise to dangerous symptoms. The stilette may be used as a plug in the needle to prevent too rapid a flow.

*Collection of the fluid.*—If possible at least two specimens of not less than 5 c.c. free from blood should be collected. The first few drops are occasionally blood-stained owing to bleeding from a small vessel during puncture; these should be neglected and only the clear fluid taken. If the fluid is evenly blood-stained throughout, puncture in another lumbar space; if still blood-stained, blood is probably present in the cerebro-spinal fluid and is not adventitious.

*Injection of sera.*—Sera may be injected by means of the Record syringe, which has been aseptically filled with warmed serum. The maximum quantity injected should be somewhat less than the quantity of fluid withdrawn.

*Withdrawal of the needle.*—The needle should be withdrawn deliberately, a piece of gauze or sterile wool being held against the skin in order to prevent dragging.

Gauze and collodion should be placed over the puncture wound.

# Section XIV.

## SURGERY OF THE FACE, MOUTH, JAWS, AND NECK.

### Plastic Surgery of the Face, Nose, Lips, and Palate.

### Plastic Methods in General.

When an *oval* area of skin has been removed, if the margins are sufficiently extensile, or if they can be raised from the underlying structures by undercutting, the margins may be sutured together to form a linear union (Fig. 269, 1 *a*, the incision for the removal of an oval area ; *b*, linear union).

If tension is excessive, relief can be afforded by semicircular incisions on either side ; the incisions gape and become semilunar areas. When the margins of the oval area are united by drawing upon the semilunar wounds, these are rendered linear and can then be sutured along a line at right angles to the main line of union (Fig. 269, 8 *a*, *b*, *c*).

Or a Y—V form of union may be adopted. Thus if, in Fig. 269, 7 *a* represents the oval area excised, a Y-shaped incision is extended out from it, and, after undercutting, the sutures can be applied to make the Y into a V, as shown in Fig. 269, 7 *b*, *c*.

If the area removed is semilunar (see Fig. 269, 2 *a*), then it may be possible to make a curvilinear union (2 *b*).

Or the semilunar wound may be retracted so as to make it quadrangular. Then, sutures being applied, commencing with each angle (see 2 *c*), a crucial union can be obtained (2 *d*).

A triangular flap may be raised so as to expose a triangular area (Fig. 269, 3 *a*), and the flap being replaced, a rectangular line of union is formed (3 *b*).

If two triangular flaps are raised, a quadrilateral area is exposed (see Fig. 269, 4 *a*) ; the flaps when reunited form a Z-shaped line of union (4 *b*).

If the area to be covered is V-shaped, the margins on each side may be raised and sutured so as to make a T-shaped line of union (Fig. 269, 5 *a*, *b*). Or if only one side can be raised (Fig. 269, 6 *a*), then the flap must be shifted across, and the line of union will form an acute angle (6 *b*).

An oval area may also be covered by raising a pear-shaped flap (Fig. 269, 9 *a*), which is twisted round on its peduncle so as to cover the oval area (9 *b*). The area exposed by the raising of the pear-shaped flap may be united in a linear fashion (9 *c*), or in some other way, including epidermal grafting.

In order to cover in a quadrilateral area (Fig. 269, 10 *a*), a rectangular flap may be raised and drawn over from one direction (10 *b*). A larger quadrilateral area may be covered by raising and drawing over flaps from three directions (Fig. 269, 11 *a*, *b*).

### Application of Plastic Surgery.

A *rodent ulcer* situated just below the inner canthus and threatening to encroach upon the lower eyelid is removed by an oval incision (Fig. 270 (*a*) ).

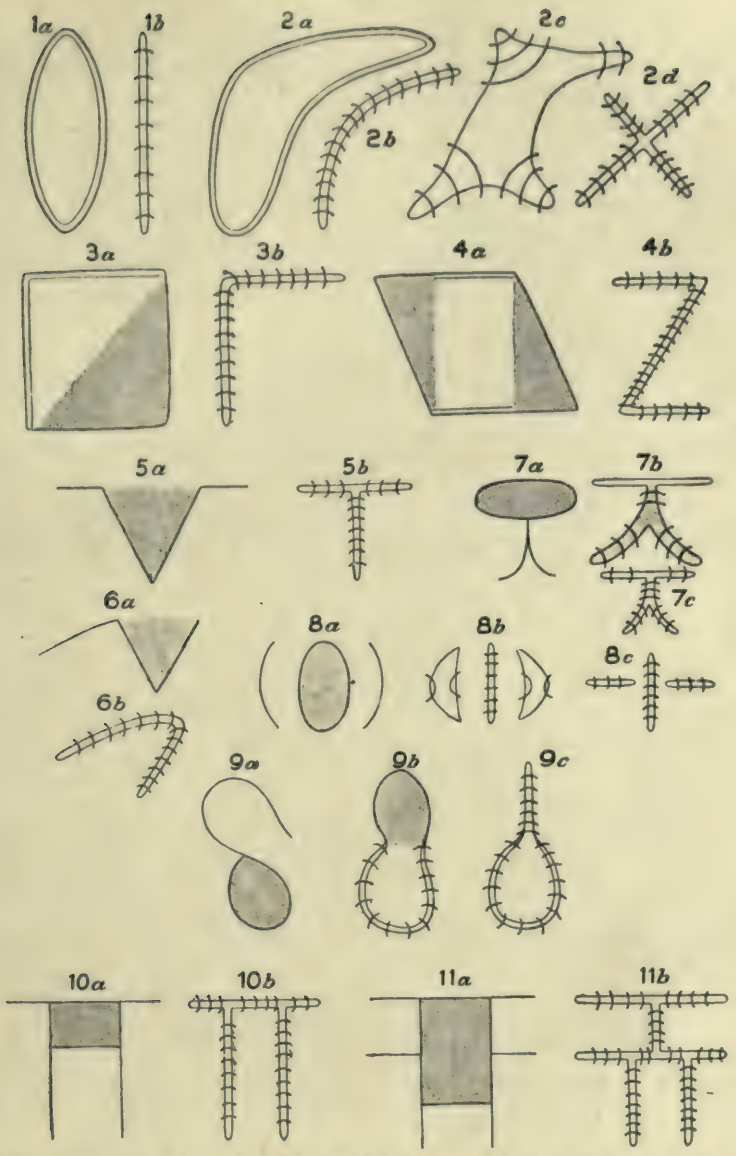



FIG. 269.—Lines of incision. 1 *a*, Incision for the removal of an oval area. 1 *b*, Union. 2 *a*, Incision for the removal of a semilunar area. 2 *b*, Union. 2 *c*, Union after retracting the semilunar wound so as to make it quadrangular. 2 *d*, Result after applying sutures to each of the angles (see *Breast*). 3 *a*, A triangular flap (shaded) turned back to expose a triangular area. 3 *b*, The flap reunited in position. 4 *a*, Two triangular flaps (shaded) turned back to expose a quadrangular area. 4 *b*, The flaps reunited (see *Lymphatic Glands in the Neck*). 5 *a*, A V-shaped area (shaded) may be covered in by raising flaps on each side and uniting them as in 5 *b*. 6 *a*, Alternatively a V-shaped area (shaded) may be covered in by raising the flap on one side only, and shifting it across so as to unite it as in 6 *b*. 7 *a*, An oval area (shaded) covered in by making a Y-shaped incision and uniting the flaps as in 7 *b* and 7 *c* (see *Epithelioma of the Lip*). 8 *a*, An oval area (shaded) may be covered in by making a semicircular incision of relief on each side. By uniting the margins of the oval area, and then by retracting the semilunar wounds, the latter are rendered linear, and are united along a line vertical to the main line of union (see *Umbilical Hernia*). 9 *a*, An area (shaded) may be covered by raising and shifting over it, 9 *b*, a pedunculated flap, after which the area from which the flap has been raised may be sutured, 9 *c* (see *Rhinoplasty, Perforation of the Palate, Excision of the Breast*). 10 *a*, To cover in a quadrilateral area, a rectangular flap may be raised and drawn over from one direction. 11 *a*, A large quadrilateral area may be covered by raising and drawing over it flaps from three directions. 11 *b*, Union.

From this an incision is carried outwards along the margin of the orbit to the malar region, then vertically downwards, but not so far as to involve the facial nerve or parotid duct. This rectangular infra-orbital flap being raised, is shifted inwards and sutured as in Fig. 270 (*b*), and will prevent ectropion of

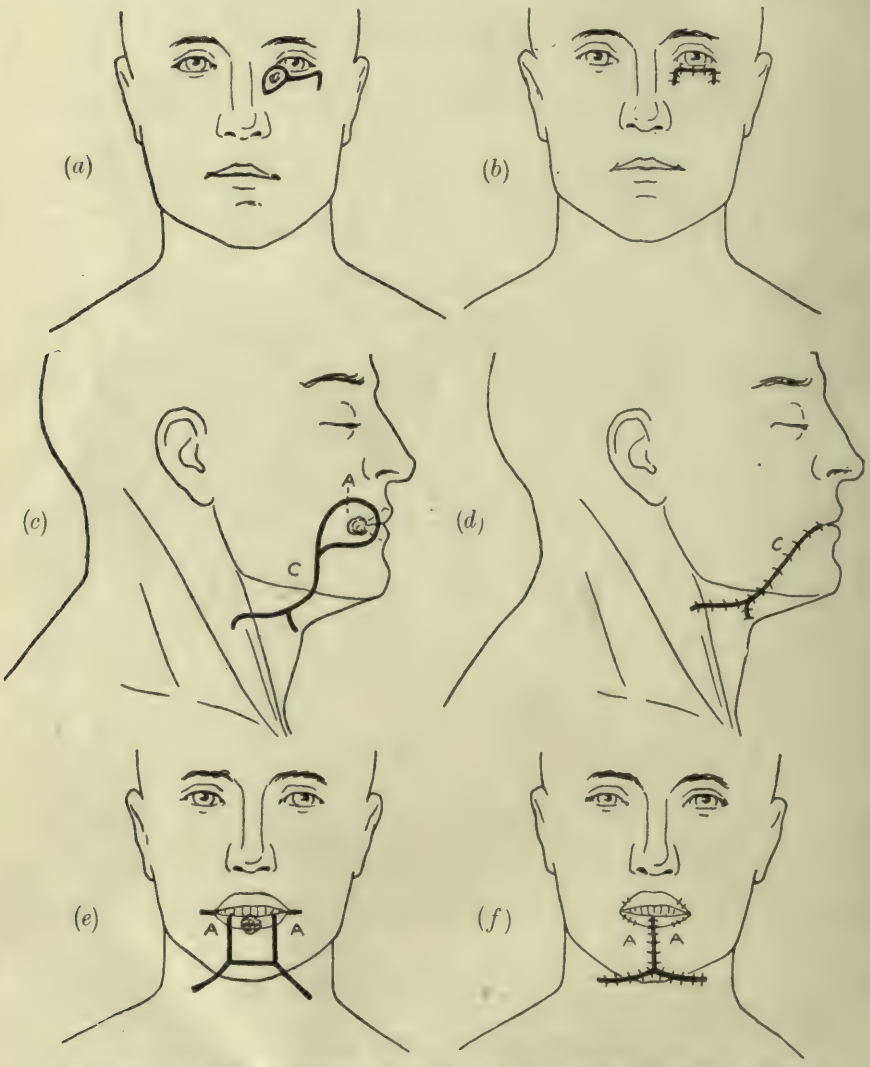



FIG. 270.—Diagrams to illustrate various plastic operations on the face and lips.

the lower lid. To avoid epiphora an extirpation of the lachrymal sac, perhaps even of the lachrymal gland in addition, may be advisable.

An *epithelioma situated at the angle of the mouth* is excised by an oval incision extending through the whole thickness of the cheek (Fig. 270 (*c*) ). From the outer end an incision is carried downwards into the submaxillary region so as to expose and remove the submental and submaxillary lymphatic glands, and if necessary those along the sterno-mastoid. The skin thus raised in a

flap from the submaxillary region can then be shifted upwards and inwards to cover the gap in the cheek (Fig. 270 (*d*)).

When an *epithelioma is removed from the lower lip* it is desirable that the line of excision should be carried vertically downwards on each side, for the older V-shaped incision sometimes left infiltrated lymphatics behind. From the lower angles of the excised area incisions are extended outwards and downwards on each side for the removal of submental and submaxillary glands (Fig. 270 (*e*)). The submaxillary flaps of the skin thus raised can then be shifted inwards and upwards, so that the line of union is as in Fig. 270 (*f*)). The lower lip is much shortened by this method, but the size of the mouth

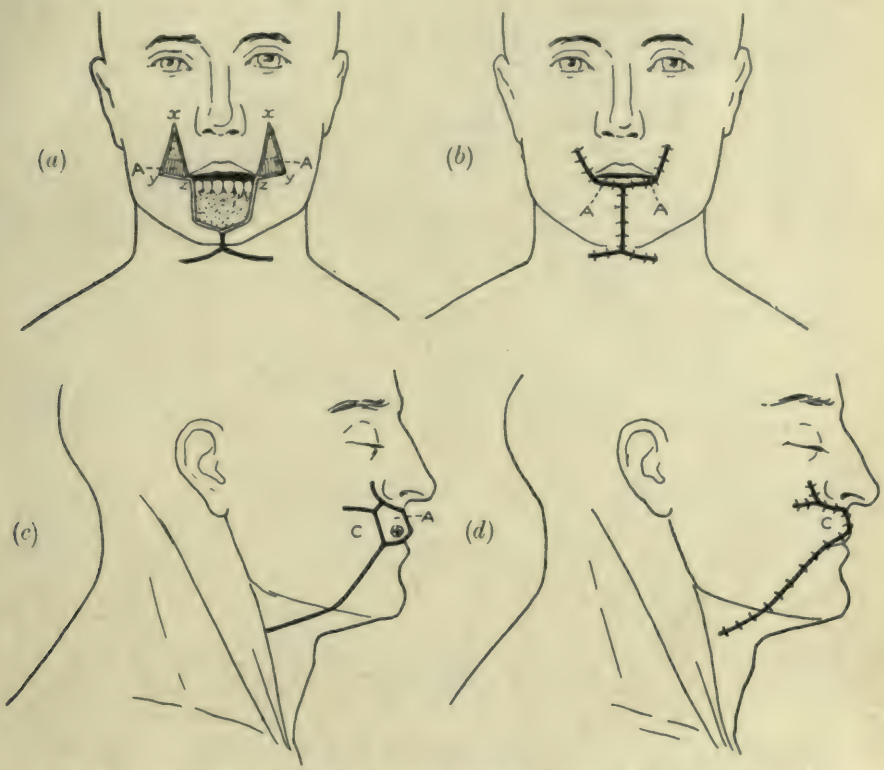



FIG. 271.—Diagrams to illustrate various plastic operations on the face and lips.

can be restored by carrying incisions horizontally outwards into the cheeks from the angles of the mouth, and suturing mucous membrane to skin over the raw areas thus produced (see Fig. 270 (*e*) and (*f*)).

In an extensive case, when the *whole of the lower lip has to be removed*, an addition is necessary to restore the prolabium. This may be done by taking a flap of mucous membrane from the inside of the cheek external to the upper lip (Fig. 271 (*a*)). The skin and superficial tissues are completely excised from two triangles (*x y z*) on the cheeks, and then on each side incisions are made into the mouth to form a flap of mucous membrane (A) hinging below on the line *y z*. When the skin margins have been brought together, these flaps of mucous membrane are stitched down to re-form the prolabium (Fig. 271 (*b*)).

A *restoration of the upper lip* may be made partly from the cheek, partly from

the submaxillary region. Thus an incision can be carried upwards along the line between the nose and cheek, also one outwards, and so a flap raised from the cheek and drawn upwards (Fig. 271 (*c*) ). Care must be taken to avoid ectropion and injury to the parotid duct.

In addition, an incision is carried downwards into the submaxillary region for the removal of glands, after which the submaxillary flap may be shifted upwards and inwards. The line of union will be as in Fig. 271 (*d*).

## Wounds of the Face.

Uncomplicated superficial wounds of the face bleed freely, but, after ligature of the facial artery or its branches and exact approximation of the edges, they heal quickly by first intention. The chief complications are : injury to the facial nerve, causing paralysis ; injury to the parotid gland and duct, resulting in a fistula ; involvement of the eyelid or mouth, resulting in disfiguration.

The uncomplicated wounds are united exactly by horse-hair or fishing-gut sutures or by clips. The line of suture is then painted with iodine, covered with a flake of wool, and sealed with collodion.

The complicated wounds, after arresting hæmorrhage, may require a nerve suture, re-establishment of the communication of the parotid duct with the mouth, or a plastic operation to prevent deformity of the eyelid or mouth.

Deep wounds, such as occur in war and from explosions, may penetrate the nose, antrum, or orbit, and even involve the cranial cavity. The penetration of the nose or antrum may be accompanied by the impaction of a foreign body, followed by necrosis and persistent suppuration. In former days large fragments of shell, etc., remained buried which would now be readily discovered by an X-ray examination. The roof of the orbit has been often penetrated by the thrust of a stick or umbrella ; also the cranium has been penetrated through the nose.

*Treatment.*—Exploration of the wound, even although very small, with excision of the damaged soft tissues and removal of the foreign body and all fragments of bone absolutely detached, disinfection, and primary or secondary suture.

*Burns* require close attention during healing, which must be supplemented by epidermal grafting, and later, if necessary, by a plastic operation.

## Rhinoplasty.

Portions of the nose may be cut off by accident, or in fighting ; in Germany in students' duels. In India and the East it has been the custom for prisoners to be so mutilated, and jealous husbands have slashed off their wives' noses. The portion cut off may include all of the cartilaginous tip and some of the upper lip. The nose, although completely detached for as long as half an hour, and even after being rescued from a dog's mouth, has been refixed and has united without much shrinkage.

To remedy the deformity so produced restoration has been made by the Indian method of a flap taken from the forehead, or by the Italian method of Tagliacotius (Tagliacozzi) of taking a flap from the arm. Epidermal grafting suffices for a superficial lesion only, and the transplantation of skin, *e.g.*, from the buttock, has not had a permanent success.

**The Indian method.**—The native operators first made a model of the nose to be restored from a sheet of wax, which was then spread out on the forehead as a pattern for the flaps. But English operators, like Keegan, have cut out a pattern of the flap in brown paper and stuck it obliquely on the forehead, an addition being made if the upper lip is to be repaired as well.

The patient having been anæsthetised and the nasal cavities plugged, the skin over the nasal bones is turned down and is employed later in forming the external nares. To do this a lateral incision is carried downwards on each side in the line between the nose and the cheek ; a horizontal cut joins these lateral incisions across the root of the nose where spectacles rest, and a perpendicular median incision bisects the nose. Then the two flaps are turned downwards upon a hinge placed where the nasal skin joins the scar.

Next, around the outline of the pattern laid on the forehead an incision is made down to the periosteum, but leaving a pedicle near the eye, upon which the forehead flap, after being raised, can be twisted round and laid with its raw surface upon the raw surface exposed by turning down the nasal flaps. The nasal flaps are rolled round drainage tubing, skin surface inwards, so as to form the anterior nares, and between them the narrow piece of the forehead flap is fitted to form the columna, below which the quadrilateral piece fits into the gap made by paring the scar in the upper lip. After putting in sutures to hold the flaps in position, the raw surface on the forehead is covered by epidermal grafts. The anterior nares being lined with skin, the drainage tubing may be soon dispensed with. After a fortnight the twisted pedicle of the forehead flap may be fashioned so as to remove the ridge.

**The Italian method** consists in covering the nose with a pedunculated flap of skin and subcutaneous tissue from the arm, which is kept fixed to the head until the flap has united, when the pedicle can be cut through. The inherent defects of this method are : the irksome position of the arm, the slightest movement of which may disturb the flap, and also the liability of such a heteroplastic flap to shrink, or even to slough off, some time after healing.

**Deformities produced by syphilis and tuberculosis** (lupus) may also be repaired by such plastic methods, but the flaps used may be unhealthy, and the disease may recur in them.

Successful attempts have also been made to repair such deformities by grafting bone, *e.g.*, a segment from a rib, into the gap.

A *sunken bridge* following injury or inherited syphilis has been improved by inserting a moulded celluloid or silver plate beneath the skin through an incision made in the line where spectacles rest. A marked improvement both in profile and full face is obtained.

The *injection of paraffin* to raise the skin has not been permanently successful, and complications have followed the spread of the paraffin to the eyelids, causing œdema, and even blindness has ensued from blocking of the retinal artery.

Other measures failing, recourse may be had to a prosthetic appliance, an artificial nose of tinted celluloid fixed on a spectacle frame.

## Hare-lip and Cleft Palate.

During the first and second months of life in the mammalian embryo the nasal cavities become separated off from the primitive mouth or stomodœum by the formation of the upper lip and palate. In extreme cases before the tenth week an arrest in development stabilises a condition comparable to a shark's mouth, in others to that of a frog, and produces the congenital deformities of hare-lip and cleft palate. Extreme conditions are met with in non-viable anencephalic monsters ; and in some cases of viable infants with hare-lip and cleft palate there occur other malformations: club-foot, spina bifida, morbus cordis, and imperforate anus. In some instances there is an obscure hereditary connexion, for these deformities recur in members

of the same family; an intra-uterine inflammation, such as syphilis, has been supposed to account for it, if not directly, then indirectly through malnutrition. Malnutrition may account for the occurrence in animals; lion cubs born in confinement are frequently affected when the mothers are not well fed.

About the third week of embryonic life the maxillary processes commence to grow forwards and inwards at the side of the primitive mouth from the upper margin of the mandibular arch, whilst from above and in front the mesial fronto-nasal process grows downwards. On either side of this latter process, at its anterior and lower extremity, appear the olfactory pits or primitive nostrils, by which the fronto-nasal process is divided into a median and two lateral processes. The median process, somewhat rectangular, becomes enlarged on each side into a globular process. Between the globular processes projects the columna, which produces the lower and anterior part of the nasal septum, whilst its upper part becomes the dorsum of the nose.

About the eighth week the globular processes fuse with one another in the middle line below the columna to form the central part of the upper lip. The line of fusion continued downwards from the columna naris forms a groove, *the philtrum*, with a ridge on either side, and on the free margin of the lip there is a projection, *the labial tubercle*. Meanwhile the maxillary processes, growing inwards below the eyes, make the cheeks, and, extending inwards below the alæ nasi, formed by the lateral nasal processes, unite with the globular processes. Next the globular processes by growing backwards establish the premaxillary elements, and the maxillary processes by growing inwards form the hard and soft palate. The palatal processes unite in the middle line with the septum formed by the mesial nasal process. Thus the nasal cavities are shut off from the mouth and from one another. The union of the uvula, which occurs last, should be completed by the tenth week.

The premaxillary elements derived from the globular processes should form tooth sacs for the central and lateral incisors, the maxillary elements for the canine and molars. When the superficial portions of the maxillary and globular processes fail to unite, whether on one or both sides, the deformity termed hare-lip is produced. This disturbs the development of the lateral incisor. Its tooth sac may be absent, when only the median incisor will appear on the premaxillary bone and the canine will erupt on the maxillary margin of the cleft. If it is developed in its normal position, then the premaxillary bone will develop a median and lateral incisor, and the cleft will appear between the incisors and canine. But the lateral incisor may arise on the maxillary side of the cleft; this may be explained by a shifting over of the tooth sac from the premaxillary to the maxillary process, or by the abnormal development of an accessory incisor corresponding to the third incisor of lower animals.

*Hare-lip* may appear as a mere notch on the free margin of the lip, to one or other side of the median groove and labial tubercle. A notch in the middle line, in place of the median tubercle, as in the hare, is very rare. Generally the cleft extends through the whole thickness of the lip into the nostril and through the alveolus.

*Single hare-lip* is more common than double hare-lip, and occurs more often on the left than on the right side. The sides of the cleft are unequal; that on the premaxillary side is generally more vertical, the prolabium is scanty and adherent to the gum and bone; that on the maxillary side slopes off towards the angle of the mouth, at its inner end the prolabium is closely adherent to the gum and jaw, whilst towards its outer end the skin and prolabium tend to be redundant and mobile.

In *double hare-lip* the central portion, representing the skin and prolabium corresponding to the philtrum, is generally shorter than natural and closely attached to the premaxillary bone, which projects unduly forward. In the worst cases, in conjunction with cleft palate, the central portion is attached to the end of the nasal septum, with a wide gap between it and the jaw on either side.

The simplest form of *cleft palate* is a bifid uvula, next a cleft in the uvula and soft palate, or the cleft may extend a varying distance forwards into the hard palate, yet without being accompanied by hare-lip. The cleft, however, may be a complete one and be combined with single or double hare-lip. The cleft as far forwards as the premaxillæ is usually a median one, with the under-edge of the vomer free in the middle line. But if the arrest in development is asymmetrical, the margin of one half of the palate may be attached to the vomer. The imperfectly developed palatal processes usually show a high arch.

Fig. 272.—Hare-lip. (A photograph kindly lent by Mr. G. P. Newbolt.)

The consequences of hare-lip, when allowed to persist, are the ugly appearance and lisping speech; those resulting from cleft palate are more serious, according to the extent of the defect. Suction is difficult or impossible, so that the child has to be fed with a spoon or by means of a slipper-shaped bottle and teat; if the milk is placed at the back of the mouth, it is swallowed readily. The child is liable to thrush and pulmonary inflammation; many die of broncho-pneumonia, diarrhœa and wasting. The teeth develop irregularly and are liable to caries; adenoids tend to appear; chronic laryngitis may produce permanent hoarseness.

Articulation is defective, and the longer the deformity remains untreated the more difficult is it as a rule for the nasal tone to be overcome after operation.

**Treatment of hare-lip.**—Hare-lip should be closed as soon after birth as possible. A few days may be necessary to clean the mouth of thrush with the aid of boric acid and glycerin. In any case the operation should be done before teething commences, and even if the child is not thriving it had better be performed before it gets weaker.

The child should be wrapped up in cotton-wool; the head may hang backwards over a pillow, the surgeon sitting behind it, or the child's head may be raised a little and the surgeon face it.

The essentials of the operation are that hæmorrhage, which infants bear badly, should be checked as far as possible; the cleft pared, so that the raw

surfaces can be brought into exact apposition; the lip freed from the jaw, so that there shall be no tension on the sutures. A tubercle should project on the free margin of the lip at the line of suture to allow for subsequent contraction of the scar, and when inserting sutures the prolabium on either side should be brought accurately into line, so that after healing it shall appear neither inverted nor everted.

The assistant holds the angle of the mouth on each side between his thumb and fingers, so as to control hæmorrhage, whilst at the same time he everts the lip. A bit of sponge attached to a strand of silk is put into each nostril to prevent blood from flowing back into the pharynx.

(*a*) When the cleft is a mere notch which does not extend through the lip, an inverted V-shaped incision is made just above the apex of the notch. This incision is made through the skin, deep into the substance of the lip, but without perforating the mucous surface, each arm of the inverted V stopping short of the prolabium. The flap formed is turned down so as to make a diamond-shaped wound, which is now united vertically by fine fishing-gut or horse-hair sutures; a projection to represent the labial tubercle replaces the notch on the free margin of the lip.

(*b*) When the cleft extends through into the nostril the external portion of the lip is raised from the gum and cheek by cutting close to the bone, aided

Fig. 273. Fig. 274. Fig. 275.

Figs. 273, 274, 275.—Operation for single hare-lip when the fissure does not extend into the nostril.

by a raspatory. The separation is continued well into the nostril, outwards nearly to the angle of the mouth and upwards almost to the lower border of the orbit. It is essential that there should be no tension when this portion of the lip is drawn inwards. The red portion of the lip is incised at the apex of the cleft, and then a flap of prolabium is partially detached by an incision which in its upper two-thirds passes vertically downwards immediately on the skin side of the muco-cutaneous junction, and in its lower third is carried horizontally outwards above the prolabium.

Next on the inner side of the cleft the prolabium with just a margin of skin is pared off, beginning at the apex of the cleft and extending outwards nearly to the angle of the mouth. The lip on this inner side of the cleft is also raised a little from the gum, but not to the extent of the other. Now the assistant pushes the raw surfaces into contact, and the flap turned downwards from the external side of the cleft will produce at the lower end the labial tubercle. At first this prominence must seem excessive, as otherwise when the scar contracts in its long axis a notch will reappear. The approximated sides of the cleft are then sutured, using interrupted sutures of horse-hair or fishing-gut.

The suturing should commence with the mucous surface, followed by the prolabium; if these sutures are inserted somewhat deeply, the margins in simple cases may be brought together, without the need of any through the skin; even if sutures are inserted through the skin of the lip they are

under no tension and can be removed after two or three days, so that persistent puncture marks are avoided. Those on the mucous surface and in the prolabium should remain until loose.

After suturing iodine is painted on, a flake of cotton-wool applied and fixed with collodion. Over this a dumb-bell-shaped piece of rubber strapping is stuck on whilst the cheeks are pressed forwards, and will prevent traction on the lip, particularly whilst crying. The child is fed with a spoon or slipper-shaped bottle; the mouth is wiped out after each feed; the lip is kept clean and dry by dusting with boric acid. When the strapping threatens to slip it must be reapplied.

(*c*) *Double hare-lip.*—If the premaxillary process is much displaced forwards, it should be pushed backwards some days beforehand, after, if need be, fracturing its connexion with the septal cartilage, or after subperichondral excision of a wedge of the septal cartilage, but without such cutting as will impair its blood supply and lead to necrosis. Rarely it may have to be cut away, preserving the skin, but then there will persist a marked recession of the lip.

The simplest way of closing a bilateral cleft is to pare away all the prolabium from the premaxillary process whilst preserving the skin, then to raise, free, and cut a flap downwards from the lip on each side. The two flaps meet in the middle line under the premaxillary process, and so supplement its defect in length. This imitates the natural course of development.

In bad cases the mouth may thus be rendered too small (*microstomia*); then an incision may be carried outwards from the angle of the mouth, and the raw surfaces so made prevented from reuniting by suturing mucous membrane to skin.

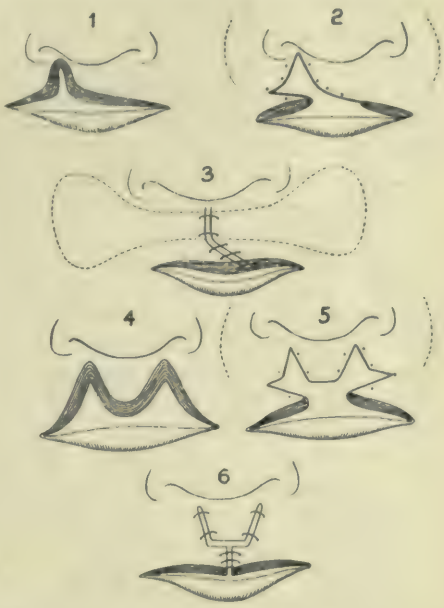



FIG. 276.—Hare-lip union. 1, Single hare-lip, the prolabium shaded. 2, A flap turned down on one side, on the other the prolabium is pared away whilst the lips are freed from the gum and jaw as far out as the semi-lunar dotted lines. Dots mark the points for the sutures. 3, The sutures knotted, and the dotted line shows the position of the dumb-bell-shaped piece of strapping. 4, Double hare-lip. 5, A flap turned down on each side and the intermaxillary prolabium pared off, the dots marking the points for the sutures. 6, Sutures drawn tight.

**Treatment of cleft palate.**—Whilst a cleft in the soft palate may be closed at any time, operations for closure of extensive clefts of the hard palate have been usually carried out after the completion of the first dentition, *i.e.*, at about two years of age; in the wide and difficult clefts the delay has been much longer. The results as to the recovery of proper articulation have shown wide variations—there have been practically perfect recoveries of speech, even when the cleft has not been closed until after puberty; on the other hand, cases of perfect closure of the cleft from the surgical point of view have shown very

little improvement, the nasal intonation persisting in spite of vocal training or skilfully fitted obturators.

Sir W. Arbuthnot Lane's recommendation of an earlier operation has been opposed by Mr. James Berry, who, in supporting the later operation of Langenbeck, has put forward the importance of the changes which go on after closure of the hare-lip, viz., a progressive narrowing of the cleft and a thickening of the tissues, after which Langenbeck's operation can be carried out more successfully and a mobile soft palate formed. When this is followed by sedulous practice in articulation good speech is obtained. Mr. Berry has exhibited a number of cases at various dates after operation, and his results have surpassed any others exhibited in London.

The chief objection raised to the late operation is that the worst cases die before two years are reached; hence, strictly speaking, the two methods cannot be compared. A child with cleft palate, unless exceptionally hardy, is very difficult to rear for the reasons mentioned above (p. 653).

Sir W. Arbuthnot Lane's advocacy of an early closure by aid of flaps has met with criticism, and he has not yet disarmed it by exhibition of results. It is objected that the immediate mortality is large; that the flaps when they slough, as they often have done, leave but little chance for success at a second operation; that even when the union is successful, the dentition is rendered still more irregular by this method of raising flaps; that the soft palate thus formed is rigid, and hence speech remains markedly defective.

There is an intermediate course between these two opposing issues. In favourable cases, when there is a cleft involving the soft palate and only the hinder portion of the hard, a Langenbeck's operation may be done on the infant, taking advantage of the enlarged aperture, before closing the hare-lip; also Langenbeck's operation may be carried out before teething after first narrowing the cleft by fracturing the maxillæ.

*Staphylorraphy* is the union by suture of the soft palate; *uranoplasty*, the closure of the cleft in the hard palate.

*Langenbeck's operation.*—This method consists in raising muco-periosteal flaps and suturing them along the middle line. If the cleft extends only partially through the hard palate, or if there is a complete cleft with the horizontal processes of the palate projecting well upwards towards the nose, like the sides of a Gothic arch, then the operation is likely to prove relatively easy. If on one side the vomer is united to the cleft, and especially when the septum deviates to that side, then the flap on that side may be raised partly from the side of the vomer.

The operation includes the following steps:—1. The paring of the cleft. 2. The raising of the muco-periosteum from the hard palate. 3. The detachment of the soft palate on its dorsal aspect from the posterior margin of the hard palate. 4. The making of lateral incisions of relief (the order in which these steps are carried out may be varied at will). 5. The suturing.

1. The paring of the cleft is done by seizing the tip of the divided uvula on one side with mouse-toothed forceps to make the soft palate tense and paring off an edge from behind forwards so as to produce a raw surface; this is continued along the cleft of the hard palate by taking off only a very fine slip up to the apex. The paring taken from the two sides will thus form the letter V. But as regards the hard palate the paring may be omitted when the flaps are scanty, always provided that the margins are well everted towards the mouth when sutured, so as to bring raw surfaces into contact.

2. The muco-periosteal flap is raised from the hard palate by making an incision of 1 cm. in length down to the bone a little internal to the alveolar

margin, so as to avoid the descending palatine artery. Into this cut a small raspatory is inserted and the muco-periosteum raised by working inwards towards the cleft, forwards beyond the anterior end of the cleft, and backwards to the firm attachment of the soft palate to the posterior edge of the hard palate. The bleeding thus occasioned will usually stop after sponge pressure; exceptionally, the descending palatine artery may require a ligature or the posterior palatine foramen may have to be plugged.

3. The palatal aponeurosis of the soft palate is cut away from the hard palate by drawing it forwards with the toothed forceps, whilst the blunt-topped scissors, curved on the flat, are passed one blade behind, and one in front between the muco-periosteum and bone; the division leaves the soft palate continuous with the muco-periosteum raised from the hard palate.

4. The lateral incisions for the relief of tension are extensions backwards, or if necessary also forwards, from those made when raising the muco-periosteum. They may be made before or after inserting the sutures, but should just suffice to relieve tension. The incisions should be extended backwards on the oral aspect of the soft palate, but only through mucous membrane. When the cleft involves the soft palate only relief of tension is obtained by snipping through the mucous membrane covering the posterior pillars of the fauces. The palatal muscles should not be cut if it can be possibly avoided.

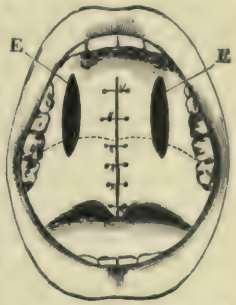



FIG. 277.—Position of the lateral incisions, E, E, through the muco-periosteum, in the operation for cleft of hard palate. The dotted line indicates the line of junction of the hard and soft palate. (Bryant's Surgery.)

5. When there is little tension a continuous suture of fine silk produces good apposition, and the margins may be made to turn towards the mouth by adopting the button-hole suture or the in-and-out square or mattress suture. Generally interrupted sutures are put in either of horse-hair or fishing-gut. They should be drawn just so tight as to bring the margins together, but not tighter, or necrosis may be set up. Silver wire is less commonly used now, but one or two sutures through the hard palate may prove useful. The wire, when twisted up with the ends projecting a little, serves as a barbed wire fence to keep the tongue from pressing on the line of suture.

A wide cleft may be first narrowed by compressing inwards the alveolar borders of the upper jaws, so that by means of a sort of greenstick fracture the maxillary bones afterwards remain approximated. There is some danger of necrosis being set up, especially if wires are inserted.

*Arbuthnot Lane's flap method.*—The children are operated upon as soon after birth as circumstances allow, and before closing the hare-lip. Hence the aperture through which the operation is carried out is wide. On one side a flap is raised by a cut along the alveolar border continued into the soft palate, the muco-periosteum from the hard palate and half the thickness of the soft palate being taken up; the flap is turned inwards, hinging on the margin of the cleft, until the raw surface faces the tongue. On the other side of the cleft, by cutting along its free margin, the muco-periosteum is raised outwards for 1 cm. or more and the soft palate split horizontally to the same extent, the raw surface looking towards the nose. The first raised reflected flap is inserted above the latter flap, between it and the bone, and the contact of the raw surface maintained by a double line of sutures.

*Cases of special difficulty.*—A pedunculated flap has been taken from the

naso-pharyngeal aspect of the soft palate, from the gum, or from the cheek, and fixed across the cleft. The operation has been done in two stages, first raising the flaps and a week later fixing them in position to obtain union by granulation. Even when primary sutures have given way, secondary suturing may succeed in obtaining union.

*After-treatment.*—The nurse must try to keep the child from crying, and from putting its fingers or any hard object into its mouth; the mouth must be cleaned without disturbing the sutures, which must be left to fall out, or are removed when they have become loose. Then follows a prolonged course of instruction in correct articulation by imitating the movements of the teacher's lips, otherwise the palatal muscles fail to develop.

**Plastic operations on the hard and soft palate** to repair syphilitic lesions may sometimes be carried out with success, if the disease has been arrested, although covering by a tooth plate may be a simpler matter.

When an adhesion of the soft palate to the back wall of the naso-pharynx has shut off the nose, and especially when the Eustachian tubes are thus blocked and there is deafness and mastoid pain, an attempt may be made to free the soft palate. This can hardly be attended with success if much of the substance of the palate has been destroyed, and the result of cutting it away from the naso-pharynx may be followed by regurgitation of food into the nose. When there is a chance of regaining a mobile soft palate, it is detached and stretched by means of a hook or finger, and then held forwards by sutures round the teeth or through the gum until the raw surfaces of the naso-pharynx have healed over.

**Congenital defects of the lower lip.**—*A notch or cleft* in the middle line of the lower lip is a very rare deformity, and is due to incomplete union of the two mandibular processes.

*Bilateral sinuses.*—Two small openings in the free border of the lower lip, one on each side of the middle line, have been met with, generally associated with hare-lip; it has occurred in more than one member of the same family, and presumably is due to an incomplete fusion, as in the preceding case. A fine probe can be passed under the mucous membrane for a short distance, and then mucus exudes.

*Treatment.*—Excision and a plastic operation as for hare-lip.

## Diseases of the Face, Lips, and Mouth.

### Diseases of the Skin of the Face and Nose.

**Erysipelas** is set up by the growth of streptococci upon some slight lesion, a mere crack being sufficient, favoured by cold, alcoholism, etc. The more dangerous attacks may be complicated by an extension to the throat, causing angina or œdema glottidis, or may spread to the scalp, which is rendered white and œdematous, and thence to the meninges, and so prove fatal. A *lachrymal abscess* when it develops acutely has been mistaken for a localised patch of erysipelas.

**Carbuncle.**—An acutely inflamed spot on the cheek, surrounded by a zone of induration which is rapidly spreading, with a dusky red colour tending to become black at the centre and the formation of vesicles around, calls for immediate diagnosis. An examination of the fluid of a vesicle or the necrosing tissue at the centre, and of the blood from the indurated area, should determine whether the infection is due to *anthrax* or to *staphylococci*. If due to anthrax the lesion and a margin of healthy tissue should be excised, carbolic acid

(1 in 20) injected in drops into the surrounding tissue, and the patient treated by Sclavo's serum. If due to staphylococci the excision may be limited to the actually necrosed tissues, combined with scraping and swabbing out with carbolic acid. Later, repair by epidermal grafting or a plastic operation may become necessary.

**Acne and sycosis.**—Acne in its simplest form is due to obstruction of the ducts of sebaceous glands in young people otherwise healthy. The face is steamed, the follicles squeezed out, and a sulphur lotion applied.

Acne pustules may result from a chronic infection by staphylococci attacking sebaceous follicles; when uncomplicated, auto-vaccination, the inoculation of a killed staphylococcal culture grown from the contents of the patient's pustules, may be expected to afford a cure.

But such pustules may appear in a patient suffering from syphilis, diabetes, etc., when further treatment is required.

In *sycosis*, when the hair follicles of the beard become attacked, it is necessary to distinguish infection by staphylococci, which depilation and auto-vaccination may cure, from cases of ringworm.

**Molluscum contagiosum** is inoculated from one child to another or from a child to its mother or nurse. It is characterised by pearly white or pinkish hemispherical swellings, varying in size from a pin's head to a pea with a depression or umbilication at the apex, which are commonly seen on the face, lips, or eyelids. They may be single or multiple and are generally discrete, but exceptionally form conglomerate masses which tend to spread. The discrete ones tend to suppurate. The interior, containing a mass of large epithelial cells arranged in polyhedral lobules, degenerates into the so-called molluscum bodies with irregular division of nuclei and the formation of keratin. The parasites causing this affection have given rise to much debate. In simple cases the swelling is punctured, the interior squeezed out, and nitrate of silver rubbed in. The conglomerate masses should be scraped away under an anæsthetic.

**Syphilis of the face.**—Syphilis must be distinguished from lupus, rodent ulcer, and epithelioma. The primary and secondary lesions should not present any difficulty. Of the tertiary lesions periostitis may attack the malar bone, and the nasal bones on one or both sides; it is important to recognise the lesion before a gummatous destruction follows.

**Rodent ulcer.**—The term "rodent ulcer" is purely a clinical one, and can only be used with exactitude when applied to an ulcer which has pursued for a year or several years a locally malignant course, extending superficially and deeply by continuity only, without infection of lymphatic glands or the production of metastases.

Hence to apply the term, in the early stages of a lesion, without the confirmation of a microscopical examination, is to make a guess at the diagnosis, and thus a so-called rodent ulcer may turn out to be a squamous-celled carcinoma or a melanotic sarcoma.

The term "rodent ulcer" may be applied with some degree of certainty to ulceration supervening upon a sebaceous adenoma. A sebaceous adenoma, which may be a "*reste*" of an ill-developed hair follicle, is most often seen a little below the inner canthus between the nose and the cheek, less commonly on the cheek, forehead, eyebrow, nose, eyelid, or temporo-malar region. It forms a little nodule about the size of a pin's head in the skin, covered by normal epidermis, or a sebaceous crust which remains stationary until after the age of fifty or sixty and then commences to ulcerate. In other cases no history of a pre-existing pimple can be obtained, the patient first noticing a little crust

or scab which frequently becomes detached. Underneath an ulcer may have slowly increased in extent and depth. This ulcer is diagnosed by its negative characteristics, the slow development, the absence of an indurated and everted margin in the healthy skin around, and the absence of glandular enlargements. On separation of the crust the ulcer presents a glazed red surface, without slough, granulations or tendency to hæmorrhage. It is nearly always single, although rarely two or more have co-existed.

When a sebaceous adenoma is examined under the microscope the appearance is that of a hypertrophy of a sebaceous gland covered on the surface by a thin layer of stratified epithelium ; when ulceration has supervened the surface is covered by small round cells, and the deeper part by branching columns formed by downgrowths of cells retaining the characteristic appearances of sebaceous gland cells.

In other cases the growth consists of cells resembling those of the deeper layers of the epidermis. Then the columns growing downwards present an interior of darkly staining cubical prickle cells, with a boundary row of short columnar cells. Between the branching columns are masses of new-formed vascular connective tissue. In particular, there is noted an absence of cell nests or ill-formed concentric layers of cells which have not become horny.

Clinically, however, in the early stage it is impossible to distinguish a rodent ulcer from a true epithelioma, or even from a melanotic sarcoma.

*Treatment.*—It should be the invariable rule to excise at once all such nodules and ulcers and submit them to a microscopic examination.

In the more extensive cases the gap left by excision is repaired by a plastic operation.

The X-rays, zinc ionisation, diathermy, radium, and carbon-dioxide snow are of service whenever the disease is too extensive for excision. Healing ensues, more or less permanent in character ; the patient returns for further treatment should any nodule, excoriation, or crust re-form. An epithelioma or sarcoma may be excited to more rapid extension by these methods.

These alternative measures should be reserved for cases already too extensive for excision. They have proved efficacious only in true rodent ulcer. But as the diagnosis of rodent ulcer is only a guess apart from excision and a microscopical examination, so the success is a matter of chance. A free excision cures the case at once ; the other methods require several sittings, frequently at some later date, to prevent recurrence.

If the application is too severe necrosis and sloughing are produced, and a scar is caused which is more unsightly than even that of an extensive excision.

**Epithelioma** arises on the face in the form of an ulcerating wart, an indurated ulcer, or a fissure deepening to an excavation. The course is usually rapid, the growth quickly extending to the bone, and the corresponding glands in the neck become involved.

Occasionally an epitheliomatous degeneration starts at more than one spot ; it has arisen as a complication of sunburn in a young person or on the weather-beaten face of an old man.

**Melanotic sarcoma** may have its origin in a pigmented mole, but the patient may not have known of the previous existence of such a mole.

The diagnosis from such chronic conditions as tuberculous ulceration or lupus, syphilis, and rodent ulcer has been referred to.

The important point is to excise all moles and nodules which show any sign of irritation, and ulcers which do not quickly heal.

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Rodent Ulcer.

## Dermoid Cysts on the Face.

Whilst a dermoid cyst may be found at any point in the line of an embryonic fissure, the only common one is placed above the outer angle of the orbit; one at the root of the nose is seen less often.

**Dermoid cyst above the outer angle of the orbit.**—An inclusion of epithelium occurs at the extreme upper and outer angle of the cleft which embraces the eyeball, and the cyst, about the size of a pea, is found in a child, fixed to the frontal bone above the outer angle of the orbit, with the skin and aponeurosis of the occipito-frontalis movable over it. It lies beneath the pericranium, and the underlying skull may present a pit or even a complete perforation. The cyst is of a simple kind, having a lining of stratified epithelium with numerous sebaceous glands, but without hair follicles, and the cyst contains sebaceous material without hair.

*Treatment.* — Excision in the line of the eyebrow by cutting through the skin and aponeurosis, which is retracted by hooks, then cutting round the pericranium outside the wall of the cyst without opening it. When the skull has been penetrated care must be taken not to injure the dura mater.

**Dermoid cyst at the root of the nose.**—This is indistinguishable from a meningocele unless the latter presents a marked impulse; hence a communication with the dura mater should be assumed. A nævus may cover the surface.

*Treatment.*—Excision. A ligature is applied to its base before cutting the cyst away.

FIG. 278—Dermoid cyst at outer angle of orbit.

## Diseases of the Lips.

**Pyogenic infections.**—Inflammations of the lip, now recognised as being caused by *staphylococcal infection*, have received names varying with the clinical appearance. In *herpes* a crop of vesicles containing serum and staphylococci appear and burst in a few days, leaving yellowish scabs and crusts. It is seen in unhealthy children, who may inoculate one another, also in cases of catarrh, especially in mouth-breathers, in the course of penumonia, and in adults suffering from dyspepsia. The detachment of such crusts leaves excoriation, cracks, and fissures; the lip, generally the upper, thickens, and formerly was known as "strumous" lip. Prolonged inflammation causes permanent thickening and scarring.

*Treatment.*—The lip should be painted with tincture of iodine, or nitrate of silver (2 per cent.) or bichromate of potash (5 per cent.) solution. Then lanolin

ointment is applied, covered by a layer of gauze or protective. A chronic fissure may be excised, and the lip, if hypertrophied, reduced in size by a plastic operation. For recurring infections a staphylococcal autogenous vaccine is the best preventative.

*Streptococcal infection* produces the dangerous condition which Paget named *carbuncle of the lip*. This may be started by a sting or by a scratch inoculating virulent streptococci. A rapid œdema of the face follows and may lead to an infective phlebitis of the facial veins. The latter may spread through the ophthalmic veins to the cavernous and other cranial sinuses, or to the meninges, or give rise to a general septicæmia.

When a black scab forms at the focus of the infection, *anthrax* must be excluded by microscopic examination.

In an acute case, whether caused by streptococci or anthrax bacilli, the focus should be cut out as early as possible by a limited excision, for destruction by sloughing is inevitable, and carbolic acid solution (1 in 20) injected around. Then streptococcal or anthrax antitoxin is administered.

**Syphilis of the lip.**—Chancre on the lip is met with in young adults, having been inoculated in kissing. There forms, more often on the upper lip than on the lower, a painless swelling surrounded by marked œdema, and there may be very little induration ; rapid œdema of a lip, not due to a wasp sting nor to erysipelas, is suggestive of chancre. The local lesion is invariably followed by considerable swelling of the submaxillary or submental glands, with much periadenitis, and generally a roseolous rash soon appears. A chancre has been produced in an infant by being put to a wet nurse. Also the infection has been conveyed by cups, spoons, pipes, and by the mouthpieces of musical instruments and of glass blowers. The diagnosis is confirmed by finding spirochætes.

*Secondary syphilis* appears as mucous patches, cracks, and ulceration about the angles of the mouth both in inherited and acquired syphilis. They are very infectious. In inherited syphilis fine scars are left radiating out on to the cheek.

**Macrocheilia,** or hypertrophy of the lip, when congenital in origin, may be caused by lymphangiectasis or by nævus, and may occur in idiots. It is also secondary to chronic inflammation and fissures.

In *lymphangiectasis* the hypertrophy consists of tough œdematous fibrous tissue containing dilated lymph spaces, and lymph vesicles project on the surface. It may accompany macroglossia. It is prone to intercurrent attacks of inflammation, with swelling of the submaxillary glands.

A *capillary nævus* on the lip is apt to be injured by the incisor teeth. A *venous nævus* may be limited and tend to become pendulous, but also may spread into the cheek, and there may be an angiomatous mass composed of large arteries and veins.

A capillary nævus may be desiccated by carbon-dioxide snow, or by diathermy, or be touched with a cautery.

For lymphangiectasis and venous nævus excision is to be done without delay whenever possible, for more superficial methods influence only the centre and rather excite the periphery to spread. When so diffuse that excision is impossible, the injection of absolute alcohol (taking care that the needle is not introduced into a vein), electrolysis, and in the most extensive cases the ligature of the external carotids are procedures which have been tried.

**Labial tumours and cysts.**—The mucous glands may become enlarged so as to appear like yellow dots, and they feel like small shot under the epithelium.

The hypertrophy of one gland may form a little tumour under the mucous

membrane, which when hard may contain nodules like cartilage, similar to a parotid tumour. Also the obstruction of a duct produces a mucous cyst.

*Treatment.*—Excision.

**Leukokeratosis and warty patches** are set up by smoking, or follow syphilis, but may be produced by a persistent inflammation in the absence of these causes. They should be excised, and not cauterised.

**Squamous-celled carcinoma or epithelioma of the lip.**—This occurs on the lower lips of old men and is often produced by smoking a short clay

FIG. 279.—Epithelioma of the lower lip.

pipe. It may, however, supervene on a syphilitic lesion and arise on the upper lip; when occurring in women they have usually been smokers. It commences as a scaly patch, a crack, an indurated tubercle, or a wart, and may either spread superficially along the prolabium towards the angle of the mouth or advance deeply into the lip. An indurated ulcer forms, covered by a dry crust, beneath which are smooth granulations. The progress is usually slow; in time the whole lip is involved and becomes fixed to the jaw by a growth which invades the bone. Meanwhile the submental glands, submaxillary, and following them the deep cervical, are involved.

The patient suffers as the result of foul ulceration from septic absorption.

Before death the enlarged glands may press upon the trachea and œsophagus, and there may be hæmorrhages. Further dissemination is very rare.

*Treatment.*—The onset of epithelioma should be anticipated by excision of a chronic fissure, wart, or patch; it is not sufficient to cease smoking; cauterisation hurries on epithelioma. A mere nodule is excised by a V-shaped incision, which can be united without a scar. If on microscopic examination epitheliomatous columns are found to have begun to grow down, the corresponding lymphatic glands should be excised.

Whenever an epithelioma has extended into the substance of the lip, a V-shaped excision is insufficient, for lymphatics between the growth and the submental glands will be left. It is necessary in this case to excise the disease by two vertical incisions continued down to the chin, which are there joined by a transverse incision through the lip, and the incision continued outwards over the submaxillary region on each side. This will enable the lymphatic glands to be raised *en masse* towards the chin, so as to include the submental glands and the lymphatics running to them from the lip. The lip must then be repaired by a plastic operation, for details of which see p. 649.

## Diseases of the Mouth, and Oral Sepsis.

**Stomatitis.**—A healthy breast-fed baby has few organisms of any kind in its mouth; when fed by hand the lactic acid bacillus grows in remains of milk and its curd. The lactic acid produced tends to irritate the gums and to encourage the growth of pyogenic organisms, which in their turn increase the muco-purulent inflammation of the mouth generally.

**Aphthous stomatitis or thrush.**—Upon any excoriation, along with staphylococci and streptococci, there may be inoculated the infection connected with the parasite known as *oïdium albicans*. This is recognised by white spots and patches in the corneous layers of the epithelium, which cannot be washed off like curd; but on wiping a patch off there is left a painful excoriation. The organism is found in the epidermis as threads of mycelium, which develop conidia-bearing cells resembling those of yeast. These cells grow out into threads, which, aided by a simultaneous growth of staphylococci, penetrate through the epithelium. Ulcers form, which may become foul and gangrenous or diphtheritic. The thrush may spread down the pharynx and œsophagus, and subsequent broncho-pneumonia and diarrhœa lead to a fatal issue. Among children badly cared for the thrush organisms are inoculated from unclean teats, spoons, and bottles, and in foundling hospitals thrush has spread like an epidemic. It may also be seen in the aged and in very exhausted adults.

*Treatment.*—The better care of the infant, especially as regards cleanliness and its isolation from others. In mild cases, besides cleaning the mouth with soft sterile gauze before and after each meal, inflamed patches may be wiped with borax and honey or with permanganate of potash, and an inflamed gum may be painted with tincture of iodine. A raw surface may be painted with nitrate of silver, 5 per cent., to form a protecting pellicle and relieve pain; a foul ulcer may be painted with bicyanide of mercury (1 in 1,000), a strong antiseptic which does not cause smarting.

**Gangrenous stomatitis: cancrum oris.**—This is a phagedenic ulceration which commences on the inside of the cheek as a dusky patch, and if not checked rapidly involves the whole thickness. It appears in weakly children who are recovering from measles or scarlet fever. There is low fever, a brawny swelling of the cheek, and fœtid breath. Cases have been neglected until too

late because the symptoms have been ascribed to toothache. If the mouth is then examined a deep foul ulcer will be found; if this is not arrested the brawny cheek soon becomes dusky, then black; the cheek is eaten away; the ulceration spreads to the gums, thence to the jaws, and into the antrum with necrosis. The child becomes comatose, and septic pneumonia may supervene before death.

In adults gangrenous stomatitis has attacked those weakened by syphilis and alcohol, especially when overdosed by mercury. It has complicated epidemics of scurvy in camps, gaols, and ships; and acute leucocythæmia may be followed by swelling and gangrenous ulceration of the gums.

The gangrenous process should be distinguished from that due to anthrax inoculation.

It appears to be a mixed infection in which it is important to recognise the dominant organism. Thus it may supervene upon measles complicated by diphtheria, and although Loeffler's bacillus is not isolated, yet the administration of anti-diphtheritic serum may prove to be the essential remedy. The same may be said concerning streptococci.

Fig. 280.—Noma or Cancrum oris. (Photograph of a specimen in the Museum of the Royal College of Surgeons.)

The spirilla and fusiform bacilli of Vincent are among the saprophytes found in and around carious teeth, but do not appear capable of setting up gangrenous lesions when inoculated into animals. However, in material obtained by excision spirilla have been found in the advancing zone of the lesion and fusiform bacilli behind the spirilla; the invasion of fusiform bacilli is accompanied by necrosis, and then in the necrosing area appear pyogenic cocci, etc. In a rapidly spreading case there is hardly any tissue reaction; in the cases tending to recovery there is an effusion of polymorphonuclear leucocytes and a proliferation of the fixed tissue cells.

*Treatment.*—A suspicious but early patch may be painted with pure carbolic acid, or perchloride of mercury in spirit (1 in 500) after taking material for pathological examination. Then, according to what appears to be the dominant organism, anti-diphtheritic or anti-streptococcal serum should be administered in full doses. Against the spirilla and fusiform bacilli of Vincent salvarsan powder in glycerin has proved of service. It may be rubbed into an

early patch, but if there is already necrosis, the dead part must first be cut away ; none of the salvarsan should be swallowed. Salvarsan (0·2 gramme) has also been administered intravenously in a child.

It has been found best to cut out the gangrenous tissue at once, free bleeding showing when healthy tissue has been reached. This offers the best prospect of saving life ; the chasm left is filled with gauze and subsequently closed by plastic methods.

## Oral Sepsis.

**The first dentition** is a normal and physiological process in which the overlying gum slowly atrophies before the advancing tooth, without any inflammation. It is an antecedent inflammation which renders dentition painful, and any tendency to convulsions should be regarded as evidence of toxic absorption rather than of reflex irritation ; lancing a congested gum produces a wound in which organisms may grow. The inflamed gum over the tooth should be painted with iodine and the mouth kept clean.

**Mouth breathing** is a change in habit from the normal nose breathing of the infant, induced by neglect and recurring catarrh and tending to become a permanent habit by the production of adenoid vegetations The open mouth becomes dry and foul from the growth of organisms. The nose is not used, and the maxilla and palate are ill developed ; the teeth are crowded, and decay is favoured.

**Dental caries.**—Ill-formed and ill-arranged teeth are the rule, and teeth with the dentine well covered by enamel and so spaced out that food *débris* does not collect are the exception. Hence it is necessary that children should be taught to clean the teeth night and morning and a life-long habit established. The organism causing dental caries attacks the thinner enamel and travels along the dental tubules. Exceptionally enamel may be chipped off. Whilst dental caries is without doubt due to organisms, no specific one has as yet been certainly identified. But by fermentation lactic and allied organic acids are produced from food *débris*, which decalcify the enamel and then the dentine. The organisms in the inspissated mucus and tartar between and around the teeth of an ill-kept mouth can attack even sound enamel. The cavities so formed in the enamel and dentine collect pyogenic and foul gas-forming organisms, streptothrix, spirilla, and fusiform bacilli.

**Pyorrhœa alveolaris** is held by some to have a purely local origin commencing with the deposition of tartar ; others have attributed the commencement to some failure in nutrition, the deposition of tartar being secondary to an irritation and exudation from the gum. At present both views may be held and the cases distinguished into two classes, the first requiring purely dental treatment, the latter general medical, including vaccine therapy, in addition to the dental.

The cases usually come before the surgeon when the mouth is foul, and there is tartar round the teeth ; pus can be squeezed up from the pockets between the gums and teeth, which are becoming loose.

*Oral sepsis* resulting from dental caries and pyorrhœa alveolaris keeps up a muco-purulent stomatitis, characterised by foul breath, and both in children and adults a wandering rash on the tongue. The jaw is attacked by periostitis, alveolar abscess, and necrosis. By extension, empyema of the antrum, follicular tonsillitis and peritonsillar abscess, suppuration in the neck, septic pneumonia, septicæmia, and pyæmia are among the acute complications. More chronic and insidious complications are now recognised as of grave importance since attention was drawn to the matter by Dr. William Hunter. The continual swallowing of pus can cause gastritis, attended by morning

nausea and vomiting, and induce pernicious anæmia; its persistent inhalation keeps up chronic bronchitis. The prolonged toxic absorption produces chronic arthritis, osteitis, and other general infections, pleural, renal, endocardial.

**Toothache** occurs when the caries has advanced sufficiently to expose the nerve endings in the dentine or pulp cavity; hot and cold water, sugar, and salt irritate and give rise to pain. A tooth cavity may be gently rinsed with warm water, dried, and then a small flake of wool squeezed out of clove oil or pure carbolic acid inserted. Toothache is often set up by cold, and then quinine in 2—5-grain doses or salicylate of soda in 20-grain doses should be given and repeated every hour or two until the pain is relieved, while the gums may be painted with iodine and aconite tincture. The pain may be due to the formation of an alveolar abscess. Also dental neuralgia may be set up by pregnancy, anæmia, malaria, syphilis, or be a symptom of trigeminal neuralgia.

The eruption of the lower third molar or wisdom tooth may be the cause of severe pain referred to the ear, throat, or neck, and the jaw may be held closed, owing to the irritation of the inferior dental nerve. The tooth may be still buried in the gum or have taken an oblique or horizontal direction, so as to become wedged beneath the second molar. A skiagram will show this.

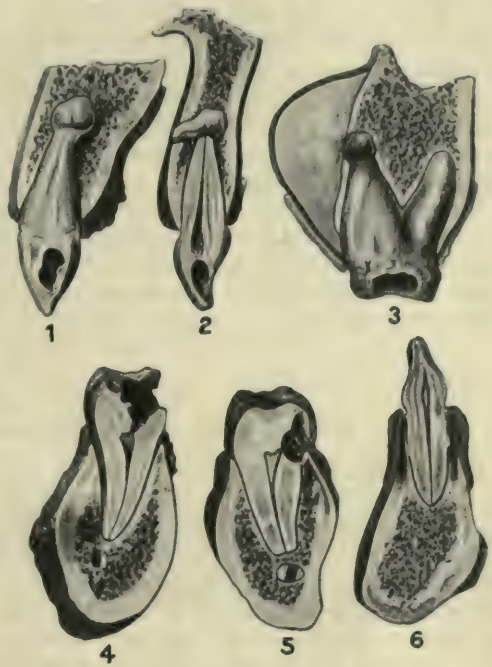



FIG. 281.—Dental suppuration and necrosis in connexion with caries (after Preisswerk). 1, Dental abscess. 2, Dental sinus. 3, A sub-periosteal abscess or gumboil. 4, Necrosis extending through the substance of the alveolus. 5, Necrosis of the alveolar margin. 6, Pyorrhœa alveolaris, pus collecting between the detached gum and the tooth.

**Oral antisepsis.** — The tooth-brush, when cleaning the teeth, should be applied not only by horizontal movements, but by scrubbing up and down, both inside and out. This is especially the case on the inside of the lower incisors close to the opening of the salivary ducts, where tartar is most readily deposited. Dentures must be removed at night and cleaned before being replaced. Fixed dentures and crowned teeth inevitably keep up oral sepsis.

To clean a foul mouth may be impossible until teeth have been scaled and hollow teeth filled or stumps removed. Short of regular dental treatment, in an adult chlorate of potash may be added to chalk powder up to 50 per cent., but it should not be used for children, and an adult must be careful not to swallow the powder. Carious teeth may be wiped out with pure carbolic acid: into foul pockets between the gums and teeth a little undiluted peroxide of hydrogen may be syringed; a sore or tender gum may be painted with iodine tincture; a painful excoriation may be painted with

5 per cent. nitrate of silver, a pellicle forming a protecting film ; a foul, acutely ulcerating, gangrenous, or epitheliomatous ulcer may be painted with bicyanide of mercury (1 in 1,000). The best general mouth wash is permanganate of potash, or peroxide of hydrogen, or, provided it is not swallowed, carbolic acid (1 in 100). A weak solution of iodine or formalin is a good deodorant. There are other pleasant mouth washes, but with feeble antiseptic properties.

The constant care of the mouth is obligatory on surgeons and nurses, and when the mouth is really free from oral sepsis, and especially whilst breathing through the nose, there is no danger of wound infection from the breath.

**Alveolar suppuration.**—Organisms entering by a carious tooth and spreading down the fang set up suppuration in the alveolus, which perforates the wall of the alveolus and causes an abscess between the gum and bone—a gumboil. On bursting through the gum it forms a sinus. Or, an abscess having thinned the alveolus, the pus tracks below the reflection of the mucous membrane into the cheek ; the abscess then points on the cheek or about the angle of the jaw, and after spontaneous opening leaves an intractable fistula. In the upper jaw the pus may spread into the antrum or beneath the muco-periosteum of the hard palate.

A superficial gumboil is punctured and the offending tooth extracted. Before this, external fomentations with the addition of opium tincture or belladonna extract are used ; or in the mouth, a bread poultice, made into a paste in a spoon with the addition of 15—30 minims of opium tincture, may be applied over the painful gum.

## Diseases of the Jaws, including the Temporo-mandibular Joint.

### Inflammation causing Necrosis of the Jaw.

**Acute necrosis** of the jaw, upper or lower, may be limited and end in exfoliation of a small fragment, or it may be more extensive and dangerous, involving half of the lower jaw, or the alveolar process of one maxilla.

The more limited necrosis is set up by carious teeth and alveolar suppuration, the more extensive by an acute staphylococcal osteomyelitis. In the upper jaw it may be pneumococcal in origin by infection through the antrum, or the necrosis may be a complication of gangrenous stomatitis. In such cases there is severe throbbing pain, deep-seated swelling, and often great œdema of the face and eyelid. A brawny swelling of the cheek may be followed by septic thrombosis, *e.g.*, of the cavernous sinus, or by some other pyæmic complication, with a fatal termination. During the acute stage the surgical treatment must be limited to letting out retained pus by a free incision ; the removal of necrosed bone must be undertaken as soon as the acute stage has subsided.

**Subacute necrosis and caries** of the jaw are set up in several ways :—

1. It may be of *dental origin*, and progress slowly.
2. A *fracture*, or the unskilful extraction of a tooth.
3. *Syphilitic periostitis and osteitis* with gummatous formation ; a particularly insidious process may cause a perforating ulcer into the nose or antrum in the early stages of locomotor ataxia.
4. *Actinomycosis*, which, whilst it may be inoculated through a carious tooth, may attack the lower jaw from the mouth although the teeth are sound. It is identified by finding the fungus.
5. *Tuberculous caries* in a weakly or otherwise tuberculous child is rare, and pursues an unfavourable course.

The two following causes of necrosis, formerly common, should not now be met with :

6. *Excess of mercury*, even calomel in excess, in weakly children, causes salivation and ulceration of the gums, followed by progressive necrosis of the jaw.

7. *Phosphorus necrosis.*—When the yellow crystalline phosphorus came into use for matches early in the nineteenth century, a quiet necrosis of the jaw ensued as a manifestation of general phosphorus poisoning, as well as of local irritation through carious teeth. The actual change in the bone is an eccentric atrophy, with a peculiar deposition of a pumice-like layer of new periosteal bone covering and adhering to the old. This becomes complicated by a persistent suppuration and foul discharge.

The disease has been prevented by the substitution of the red amorphous phosphorus for the yellow variety, and by regulations as to cleanliness and teeth inspection among workers. But susceptible patients return to such work after their recovery at a great risk of relapse.

*Treatment.*—As soon as bone begins to necrose it should be removed subperiosteally; to wait, encourages the onset of septic complications.

## Tumours of the Jaws and Teeth.

Many of the tumours or new growths forming in the jaws are now traced to abnormalities in connexion with the development of the teeth. The simplest forms owe their origin to a tooth remaining unerupted and buried in the jaw; this unerupted tooth may be a supernumerary one. Congenital *restes*, which do not develop into a tooth, may give rise to a new formation or *odontome*.

These may be divided into: —

(*a*) *Restes* connected with the enamel organ, giving rise to odontomes of epidermal origin.

(*b*) *Restes* connected with the tooth papilla, producing central sarcomata, mesoblastic in origin.

(*c*) The epidermal and mesoblastic new growths may be mixed.

In addition to the odontomes, irritation affecting the gum may produce a benign *epulis* or an *epithelioma* which then invades the jaw.

*Periosteal sarcomata* of a malignant type arise on the lower and upper jaws.

## Odontomes.

A **calcified odontome** is attached to or replaces a tooth.

A **cementome** is formed by the ossification of a thickened tooth follicle in which the tooth is embedded.

A **radicular odontome** grows from the roots below the crown, and is formed by dentine internally and cementum externally.

A **compound odontome** forms an ivory exostosis on the alveolar border of the jaw; in the upper jaw it may grow towards the nose or antrum, and is composed of all the elements of a tooth arranged in an irregular manner.

A supernumerary tooth or calcified odontome may be examined by transilluminating the jaw and by an X-ray photograph.

*Treatment.*—The new growth comes away when the tooth is extracted; when more firmly seated, the gum is detached and the alveolus cut away with a chisel or burr.

**Follicular odontome, formerly termed a dentigerous cyst of the jaw.**—A tooth may remain unerupted, enclosed in its follicle, which slowly distends into a cyst having the more or less well-formed tooth attached to the inside of the cyst. In the lower jaw the usual site is in the position of the second or

third molar in front of the angle. The horizontal ramus slowly undergoes eccentric atrophy whilst new periosteal bone is laid down externally. Gradually the eccentric atrophy overtakes the new periosteal bone formation. Then the bony wall of the cyst becomes so thin as to yield to pressure and gives rise to the sensation known as *egg-shell crackling*. Later, when the wall becomes fibrous, fluctuation is felt. In the upper jaw the extension is towards the antrum or nose, and then follows swelling of the cheek. Ultimately rupture and a persistent sinus, or fracture of the lower jaw, have happened in neglected cases. The diagnosis is made by noting a slow, relatively painless, translucent enlargement without inflammation, and the unerupted tooth is seen in a skiagram.

*Treatment.*—The cyst is freely laid open ; this is done from the mouth, whenever possible, to avoid scarring. The tooth is removed, the wall scraped, the shell of bone crushed inwards to reduce the cavity, and the remainder of the latter plugged with gauze. In the case of the lower jaw care must be taken to avoid a fracture, *e.g.*, by temporarily applying a leather or gutta-percha splint.

**Epithelial odontomes** were formerly termed " cystic tumours of the jaw." Sir Frederick Eve has shown that these are relatively benign composite epithelial odontomes, arising from dental *restes* in connexion with the enamel caps and the dental papilla, which produce epithelial and connective tissue elements. On section the growth has a multilocular, cystic, honeycomb-like appearance, the cysts containing white or brownish mucous fluid. Under the microscope strands of epithelial cells show at their growing margins the regular columnar cells of the enamel organ. In the centre of the epithelial strand myxomatous degeneration causes an appearance like the enamel pulp or reticulum, and this ends in forming a cyst. Between the strands are masses of embryonic or fibrillar connective tissue.

Fig. 282.—Radicular odontome.

Clinically these tumours are distinguished by growing slowly, only reaching a large size after years ; in the case of the lower jaw there is a spindle-shaped enlargement; in the upper jaw the tumour may grow towards the antrum, cheek, mouth, or nasal cavity.

*Treatment.*—Excision limited to the tumour, along with the soft structures and bone immediately around.

**Carcinoma of the jaw : Malignant epithelial odontome.**—Carcinoma of the upper jaw of old people is a specially malignant, burrowing, epithelial growth which was formerly supposed to arise from the columnar-celled epithelium lining the antrum. But, in view of the structural resemblances to the more benign epithelial odontomes, Sir Frederick Eve traced them to a similar origin. The growth is composed of columns of spheroidal-celled epithelium with columnar cells at the periphery of the columns. Between these columns is a stroma which tends to mucoid or colloid degeneration, and near the surface to suppuration and gangrene. There is an absence of cell-nest formation.

The first sign of the growth in the upper jaw is a dull pain from pressureon branches of the fifth nerve ; later, fungation into the nose or naso-pharynx causes obstruction. There is muco-purulent discharge and hæmorrhage, or dense induration of the cheek followed by pressure on the eyeball or the infundibulum from the frontal sinus, a pressing downwards of the palate, or a perforation from the antrum into the mouth.

The glands under the jaw enlarge early, unfortunately also the deep cervical glands in front of the vertebræ. The patients generally die from septic pneumonia before metastases develop.

The diagnosis is made by examining the nose and naso-pharynx, when, although the most prominent part of the growth may appear myxomatous, there is a broad attachment which bleeds readily. On transillumination the jaw is found to be opaque, but less so than in the case of an empyema; an exploration should be made towards the antrum by retracting the upper lip.

*Treatment.*—Removal of the upper jaw and glands in the neck. The majority of cases are unsuccessful owing to early extension, in particular towards the spheno-maxillary fossa and the prevertebral glands.

## Connective Tissue New Growths.

**Single osteomata** may be perhaps considered as one of the forms of odontomes, whether projecting from the surface as an exostosis or slowly enlarging the upper or lower jaw.

FIG. 283.—Follicular odontome or dentigerous cyst. Photograph of a specimen in the Museum of the Royal College of Surgeons. The tooth lies in a cavity formed by the wall of a dilated tooth follicle.

**Multiple osteomata,** called **leontiasis ossea,** attack the jaws along with other facial and cranial bones within the distribution of the fifth nerve. They are composed of vascular cancellous bone taking the form of nodular out-growths, and usually beginning in early life. There is first neuralgic pain in the branches of the fifth nerve, then increasing facial deformity, followed by encroachment towards the nose, orbit, and brain, or limitation of movement of the jaw.

*Treatment.*—Iodide of potassium and salvarsan may be tried, for perhaps some have a syphilitic origin. Aspirin may relieve pain. Partial removals may be tried in order to relieve pressure on nerves.

**Myeloid sarcoma** arises in young people. If in the lower jaw, there is a slow spindle-shaped enlargement of the horizontal ramus, affecting the free border; the bone becomes so thin as to yield to the fingers, when *egg-shell crackling* may be felt, and with the disappearance of the bone a soft elastic swelling; if the growth bulges towards the mouth, a bluish swelling is seen under the mucous membrane. In the upper jaw there is a slow swelling of the cheek, and a bluish bulging beneath the gum. From a follicular odontome it is distinguishable on X-ray examination by the absence of a tooth. In neglected cases fungation occurs into the nose, or mouth, or through the tissues of the cheek, attended by free, and later fatal, hæmorrhage. The growth is recognised on incision by its maroon colour and vascularity.

*Treatment.*—Scraping out the cavity most thoroughly, crushing the shell, and packing the cavity remaining to arrest hæmorrhage. In advanced cases a partial excision of the jaw is required.

**Periosteal sarcoma,** composed of spindle and round cells, grows on the surface of the upper jaw and the free border of the lower jaw with great rapidity, quickly causing fungation and enlargement of the lymphatic glands.

*Treatment.*—Early and wide excision, including the glands; but the prognosis is bad. Excision may be followed by a course of Coley's fluid.

## Operations on the Jaws.

**Excision of the upper jaw.**—In most cases a *preliminary laryngotomy* is necessary, followed by packing of the pharynx to prevent blood from entering the trachea. For this may be substituted *intratracheal administration* of the anæsthetic. *Complete excision* is begun by an incision through the middle of the upper lip, along the groove between the nose and cheek, then horizontally below the eyelid to end over the malar bone. The cheek is then raised and the facial artery secured. After cutting along the middle line of the palate, the maxilla is divided by means of a saw and by forceps through the alveolar border and palate, through the nasal process, and through the malar bone. The maxilla being removed, the branches of the internal maxillary artery should be seized and tied. The cavity left is first plugged, later irrigated. The resulting deformity may be reduced by a denture. *Partial excision* includes the removal of the alveolar border; the orbital plate is preserved.

**Excision of one half of the mandible.**—An incision is made along the lower border of the horizontal ramus, and this is continued up the posterior border of the vertical ramus nearly to the tip of the lobule of the ear. In most cases the lower lip must be also divided down the middle line. Next the muscles attached to the mandible are divided. The bone is sawn through just to one side of the middle line, then depressed, the temporal muscle divided, and finally the condyle disarticulated. The facial artery must be ligatured; injury to the internal maxillary may be avoided.

Excision of a segment of the mandible may sometimes be done by using an electric motor saw and leaving a bridge of bone along the free border. If a complete segment of the mandible is cut out, the operation must be done in association with a dental surgeon and a dental splint fitted at the time of operation. Subsequently a bone graft may be inserted.

## Diseases of the Temporo-mandibular Joint.

**Deformity.**—Disturbance in the development of the first branchial arch, in Meckel's cartilage and in the bone around, causes an imperfect formation of the external and middle ear, the vertical ramus of the jaw, and its articular process. The side of the face is flattened and the chin deviated to the opposite side. Hearing is defective.

**Arthritis.**—Acute suppuration may follow otitis media purulenta, which spreads to the joint along the tympanic artery through the Glaserian fissure—*e.g.*, as a complication of scarlet fever. It may also occur in the course of pyæmia. *Subacute arthritis* may be rheumatic or gonorrhœal in origin, and there is a tendency to fibrous ankylosis. *Chronic arthritis deformans* may follow the subacute form, or occur in locomotor ataxia.

**Closure of the jaw: stiff jaw.**—*Spasmodic closure*, by spasm chiefly of the

masseter muscles, occurs in women from emotional excitement and as an occupation cramp in public speakers. Reflex spasm is particularly caused by the irregular eruption of the third lower molar or wisdom tooth, but occasionally may be set up by irritation in connexion with other molars. The condition must be distinguished from parotitis, in which the mouth is not opened owing to pain.

If the mouth is tightly closed, the patient is anæsthetised by gas and a dental prop inserted. If it is an occupation spasm, rest from public speaking is necessary, or the condition may get worse. The cause of reflex spasm must be sought out and removed.

**Intrinsic ankylosis,** or adhesions between the joint surfaces with thickening and contracture in the capsule of the joint, may result from injury, fracture or subluxation, or from disease, *e.g.*, rheumatic or gonorrhœal inflammation.

*Treatment.*—The joints should be fomented with hot water followed by active movements, stretching open the mouth with a gag and inserting a rubber block between the teeth. This should be worn at night, if the joint is stiff in the morning. In rheumatic and gonorrhœal inflammation improvement may follow auto-vaccination.

Forced opening by a screw gag under an anæsthetic is rarely satisfactory owing to relapse; the jaw is liable to fracture owing to atrophy from disuse.

To relieve established ankylosis, the condyle must be excised.

**Extrinsic ankylosis of the jaw.**— This is due to contracture of the skin, muscles of the jaw and cheek, and the mucous membrane of the mouth after burns, cancrum oris, necrosis of the jaw, syphilis, and lupus. It may be prevented by stretching during healing and by epidermal grafting.

*Operation for extrinsic ankylosis.*—The only satisfactory operation for extrinsic ankylosis is a wedge-shaped excision of the angle of the jaw. Alternatives, such as osteotomy, excision of the neck of the condyle, division of cicatrices within or without the mouth, and detachment of the masseter, have been followed by relapse.

In addition a puckered and contracted scar at the angle of the mouth may be improved by a plastic operation and by skin grafting.

## Surgery of the Tongue.

### Ankyloglossia: Tongue-tie.

*Congenital tongue-tie is an imaginary deformity;* surgeons of large experience have never seen anything worthy of the name. In a baby the tip of the tongue is relatively very short, the frænum joining the tongue much nearer the tip than in the adult. As the child grows the tip elongates; in some this takes place later than in others, as is also the case with dentition and learning to speak. But the child can move its tongue and protrude it between the gums and lips. It is quite wrong, because a child does not take the breast well, to ascribe it to a short frænum; and it is equally wrong to think that lateness in speaking or stammering has any relation to a short frænum. As a result of this error the frænum has been divided with much harm; midwives have torn through the frænum with the finger-nail and caused the death of the child from sepsis, from hæmorrhage, and from stripping back the tongue—the child has been choked, the tip curling back and becoming impacted in the pharynx (tongue swallowing). Should the child escape the immediate effect of this wrong practice, the scar formed may tie down the tip of the tongue.

**Acquired ankyloglossia** has followed severe ulcerative stomatitis, phagedena,

and cancrum oris. In former days it was frequently set up by the ulceration following excessive doses of mercury. The tongue thus became fixed to the gum, cheek, or floor of the mouth. Such adhesions may be divided and the raw surface sutured.

**Injuries to the tongue.**—The common injury by a jagged tooth may be followed by a chronic ulcer and eventually by epithelioma. The tip of the tongue may be bitten off by a blow on the chin, but the accident more usually occurs in the course of an epileptic fit, when no one is at hand to put a gag in the mouth. When the piece is incompletely detached it should be sutured into place; when completely bitten off the raw surface should be closed by sutures. Severe laceration may occur as a complication of fracture of the jaw, or be caused by a bullet, when ligature of the lingual artery may be required to arrest hæmorrhage. A foreign body, a pipe stem, a tooth, etc., may be driven into the tongue and may be discovered by probing, or by X-rays if the point of entry has been overlooked and the wound has healed over.

When about to extract a foreign body one must be prepared to control hæmorrhage, for a pipe stem has punctured the internal carotid artery and fatal hæmorrhage followed its withdrawal.

Fig. 284.—Lymphangioma or lymphatic nævus on the tongue. (Photograph of a vertical section showing dilated lymphatic spaces containing lymph.)

## Macroglossia, or Hypertrophy of the Tongue.

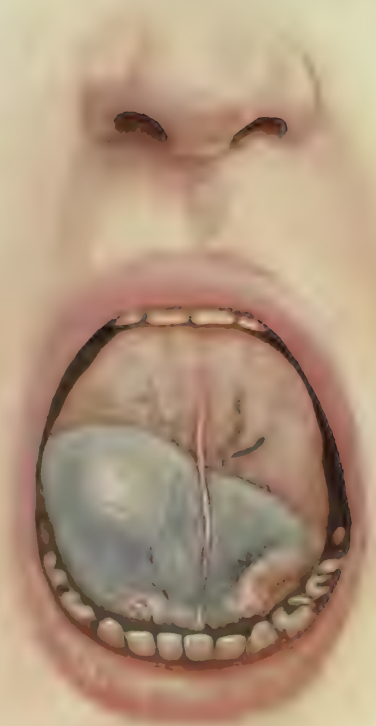
*Lingua plicata*, or *scrotal tongue*, may be seen in children, sometimes in more than one member of the family. It may be merely a congenital variation from the normal. On the other hand, it may be the superficial manifestation of one of the varieties of macroglossia. The epithelium covering the dorsum of the tongue is abnormally thick, and there are deep folds arranged cross-wise, in which food *débris* and organisms tend to collect and cause recurring attacks of glossitis. This may be prevented by painting the tongue with a solution of permanganate of potash or other non-irritating antiseptic.

**Congenital macroglossia** may be muscular, lymphangiomatous, arterio-venous, lipomatous (see p. 680), or neuro-fibromatous in character.

*Congenital muscular macroglossia* usually occurs in patients of weak intellect. The hypertrophy may be unilateral, accompanied by hemi-hypertrophy of half the face and body. The tongue lolls out of the mouth and may be ulcerated by the teeth, but it is not a progressive lesion, and no special treatment is required, except some form of respirator to protect against cold and dry air.

*Lymphangiomatous hypertrophy* often begins as a lymphatic nævus. There is a patch on the tongue covered with vesicles—some translucent containing clear lymph, some red from arterial blood, others blue from venous blood

LYMPHATIC NÆVUS OF THE TONGUE.
(After the late Sir Henry Butlin, St. Bartholomew's Hospital Museum.)



RANULA.
(After the late Sir Henry Butlin, St. Bartholomew's Hospital Museum.)

(see Plate 13 A). Underneath in the muscular substance of the tongue are dilated spaces filled by lymph; between the spaces there is an œdematous fibrous tissue which replaces the muscle fibres, and in spots lymphomatous masses of small round cells collect. This is a progressive lesion, subject to intercurrent attacks of inflammation, for the vesicles rupture and expose a raw surface, causing septic infection, glandular swellings, and fever, lasting some days. Each attack causes an increase in the size of the tongue. The tongue cannot be contained in the mouth; the lower incisor teeth cut into its under-surface and cause foul ulcers, whilst the pressure makes these teeth and the middle portion of the lower jaw turn outwards. The protruding tongue becomes dry and chapped in cold weather. Besides the complications following ulceration and hæmorrhage, the lymphomatous masses may become more and

FIG. 285.—Acquired macroglossia.

more prominent, and finally there may be a fatal growth of small round-celled sarcoma.

*Treatment.*—If seen early a lymphatic nævus should be excised freely, cutting through healthy muscle and closing by suture; later, a large portion of the tongue must be removed.

*Angiomatous macroglossia caused by a venous or arterio-venous nævus* is also a progressive lesion, and, as soon as the teeth appear, recurring hæmorrhages may be occasioned by biting the tongue. There is a soft bluish swelling, readily reducible on pressure, quickly refilling and enlarging on forced expiration. If arterio-venous it pulsates. If not treated, the venous dilatation tends to spread to the cheek and under the jaw, and there is an increasing arterial dilatation. It is far better to excise at once, having first, in diffuse cases, ligatured the lingual and facial arteries. Where this has not been done the angiomatous condition has become widespread; then injection of absolute alcohol, avoiding the puncture of veins, is the treatment attended by least danger.

*Neuro-fibromatous macroglossia* has appeared as a slowly increasing enlargement of half the tongue along with a submaxillary swelling. The surface of

the affected half showed enlarged papillæ, whilst the submaxillary swelling proved to be a plexiform mass of greatly-thickened tortuous nerve fibres.

*Treatment.*—Excision.

**Acquired macroglossia** is commonly caused by syphilis ; it may be a feature of acromegaly.

*Acquired syphilitic macroglossia* follows gummatous ulceration. The tongue is too large for the mouth owing to the inflammatory fibrous tissue, and scars and fissures cover the surface. Food *débris* and organisms collect in the fissures and set up recurring attacks of inflammation, which may be followed by epithelioma. Mercury, iodide of potassium, and neo-salvarsan have little effect in a case of old standing. The chief relief is obtained by keeping the folds and fissures clean and disinfected. Bicyanide of mercury (1 in 1,000) may be painted on with a large camel's hair brush once or twice a day and the mouth then rinsed out.

## Glossitis.

**Acute parenchymatous glossitis,** or deep inflammation of the tongue, is especially caused by the inoculation of streptococci. In animals and occasionally in man it has been due to inoculation by anthrax, trichinosis, or foot-and-mouth disease.

The inoculation of streptococci may be traced to the bites of a tooth, to the sting of an insect, or other injury ; alcoholism, mercurialism, and exposure to sewer gas all increase the severity of the disease.

In very severe cases the tongue rapidly swells and fills the mouth which is kept open, whilst ropy saliva pours out, as it cannot be swallowed. Both deglutition and speech are interfered with, and the disease may quickly spread to cause œdema glottidis, brawny œdema of the neck, mediastinitis, pericarditis, and death.

If the inflammation is more limited a sublingual or submaxillary abscess may form, or only half the tongue may be affected.

*Treatment.*—In the severe cases superficial longitudinal incisions along the dorsum of the tongue, and antistreptococcal serum in full doses, may check the œdematous swelling ; but laryngotomy should be done early if there is any sign of dyspnœa. A median sublingual abscess is opened by a vertical incision between the chin and hyoid bone, then thrusting forceps between the genio-hyoglossi into the abscess cavity, after which a tube is inserted.

**Subacute glossitis.**—A subacute glossitis leading to the formation of an abscess in the tongue may follow the bite of a tooth or other injury, or the introduction of a foreign body, when the infective organism will probably be found to be staphylococci ; or the inflammation may be caused by syphilis, tuberculosis, actinomycosis, a dermoid cyst, or by epithelioma.

*Treatment.*—Incise, and examine both the contents and wall of the abscess.

**Chronic glossitis** is set up by oral sepsis, especially by carious teeth in children ; in adults by pyorrhœa alveolaris, and by dentures when fixed or applied over stumps ; it is caused also by smoking and chewing tobacco and betel-nut, by syphilis, tuberculosis, and actinomycosis. The irritant may set up (1) a temporary inflammation which subsides on the removal of the cause, or establish (2) a persistent inflammation which continues after the cause has been removed and may progress to epithelioma.

**Temporary chronic superficial glossitis** :—

(*a*) The tongue is furred, irritable, and the breath is foul from gas-forming organisms. The sublingual folds are swollen ; there is an increase of saliva containing sticky muco-pus.

(*b*) A *wandering rash* spreads over the tongue, the so-called *geographical rash* because it has seemed to resemble the outlines of a map. The importance of the rash is that it is due to oral sepsis, and it is a blunder to suppose a syphilitic origin. Also to regard such a rash as "dyspeptic" in origin draws away attention from its local causation.

(*c*) *Herpes of the tongue and mouth.*—This term should be limited in its application to eruptions of vesicles which tend to recur, especially on the side of the tongue and cheek. The raised epidermis becomes detached and leaves a painful excoriation, so painful that mastication becomes difficult. Healing follows, but a fresh attack recurs in a week or two. If neglected, excoriation may deepen into an ulcer.

(*d*) *Exfoliative glossitis* is a more severe form in which the epidermis peels off in flakes.

(*e*) *Overgrowth of papillæ*, so-called *papillitis*. — As a result of oral sepsis the papillæ may become unusually swollen and the epidermis covering them thickened, either the circumvallate papillæ, the fungiform, or the foliate papillæ at the side of the tongue immediately in front of the anterior palatal fold. The last-named, whether because overlying the lingual nerve or because irritated by the teeth, become particularly tender.

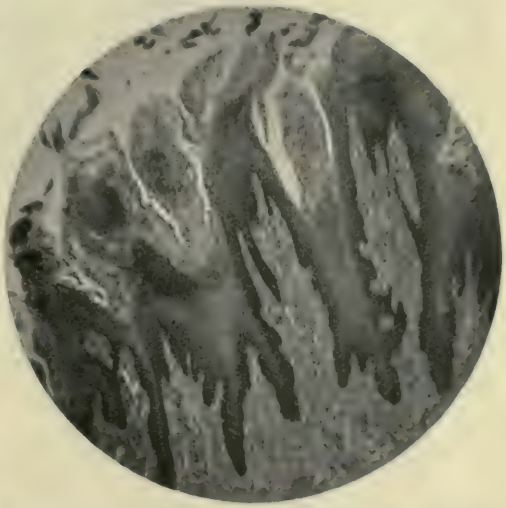


FIG. 286.—Leukoplakia. A section through a warty patch on the tongue of a smoker which was becoming an epithelioma. The epithelium is thickened, especially the horny layers; the interpapillary processes of epithelium have grown downwards, and have begun to sprout out; the sub-epithelial tissue is infiltrated by leucocytes.

(*f*) *Melanoglossia*. — An overgrowth of the filiform papillæ occurs upon the part of the tongue least subject to friction, viz., the dorsum, in front of the circumvallate papillæ. The papillæ may grow out into long filaments, which have a bluish-black colour and appear like hairs. This produces the so-called *black hairy tongue*. Much has been written as to its causation by a specific organism, *oösporon*, and of the production of the black colour by a special pigment. But, at present, neither the causation nor the pigmentation can be distinctly differentiated from other causes of oral sepsis.

As for the causation of such conditions by dyspepsia, alcoholism, etc., anything which diminishes the quantity of saliva and leads to a dry mouth favours oral sepsis, and therefore to this extent influences glossitis; but sepsis, from whatever cause, is the principal factor.

*Treatment.*—On the removal of the cause the tongue may return to the normal. After excluding syphilis, tuberculosis, actinomycosis, and restricting or forbidding the use of tobacco, the teeth must be treated or extracted, and dentures regularly removed and cleaned. Unless this is effectively done the lesions may become persistent. The raw surface left by desquamation of epithelium may be covered by painting with nitrate of silver (10 per cent.).

There is no object in scraping off the patch in a black or hairy tongue; it will disappear spontaneously with the oral sepsis, and if sepsis persist, it will re-form after being scraped off.

**Persistent chronic superficial glossitis.**—This is the term which should be used for a persistent inflammation of the deepest layers of the epidermis, and of the subepidermal tissues of the tongue and cheek, which does not disappear with the removal of the cause. The disease is marked by a proliferation of the deepest row of the stratified epithelium, by an increased thickness of the superficial layers of the epidermis with a greater projection of the papillæ, and by prolongation downwards of the interpapillary processes of epithelium. Beneath the epidermis there is a collection of small round cells occupying the submucous tissue, which may invade the underlying muscle, and in long-standing cases a formation of fibrous tissue.

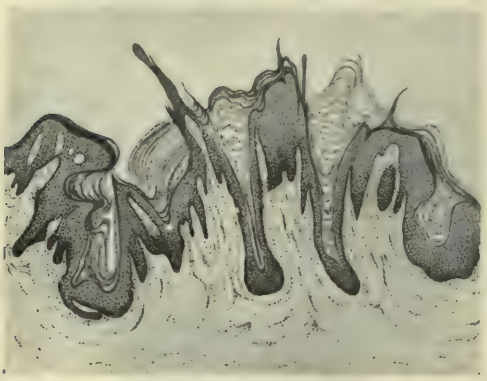


FIG. 287.—Section through a tongue with chronic glossitis. The epithelium is greatly thickened, and numerous processes project towards the surface.

The patches have been termed *psoriasis*, from a superficial resemblance to the silvery white patches of psoriasis on the skin. When the patch has consisted of an excessive heaping up of the epidermis, which is cracked and nodular, it has been termed *ichthyosis*, from its likeness to that congenital lesion of the skin; also it has been called *leukoplakia*, meaning white patch, or *leukokeratosis*, from the heaping up of whitish horny epithelium.

True psoriasis of the skin has not been seen to invade the tongue, but lichen planus has done so, the patch of leuko-keratosis not being then distinguishable from other cases of chronic superficial glossitis.

The distinguishing feature of persistent chronic superficial glossitis is that when the cause has been removed, an irritating tooth extracted, pyorrhœa arrested by extraction, smoking stopped, syphilis efficiently treated, the patch persists. If with the cessation of the cause a patch tends to disappear, this may be hastened by painting with bichromate of potash (grs. x. ad ʒj.) as a mild astringent to reduce chronic inflammation, or by bicyanide of mercury (1 in 1,000) or peroxide of hydrogen to check the growth of germs in the pus covering the patch, or if syphilitic, by mercurial ointment rubbed into the patch with the finger tip, or by painting on a solution of salvarsan in glycerin.

But any patch which is warty, or in which the epidermis has separated leaving a bare, irritable, raw surface, or a patch which has induration underneath, or which shows any fissuring or ulceration, must be excised forthwith. It should be considered the immediate *precursor of epithelioma*.

This is *the one way in which the onset of cancer can be anticipated*. The application of caustics or the cautery hastens the development of cancer.

## Plate 14a.

LEUKOPLAKIA. (After the late Sir Henry Butlin, St. Bartholomew's Hospital Museum.)
A raised nodular and warty patch on the side of the tongue.

## Plate 14b.

LEUKOPLAKIA (*ibid.*).
The tongue appears covered with a smooth white film, like size, with puckering, and on the centre of the tongue is a raised indurated nodule of commencing epithelioma.

## Syphilis of the Tongue and Mouth.

A **primary** sore may be inoculated by kissing, through a pipe, by the mouth-piece of a musical instrument, in glass-blowing, or by wooden cups and spoons used in common. An œdematous swelling is occasioned, in which the œdema obscures the induration, and it may be met with on the tip of the tongue, or on the sides of the cheek or fauces, with or without history of a pre-existing lesion. It is followed by a marked enlargement of the corresponding glands and by a secondary rash. The diagnosis is confirmed by finding spirochætes.

**Secondary syphilis** attacks especially the sides of the tongue and the inner surface of the cheeks. The earliest lesions are the mucous patches, swollen areas of mucous membrane, with desquamation of the epidermis leaving a raw surface. Then follow oval or serpiginous ulcerations, with sharply cut edges and an ash-grey base, surrounded by an areola of inflammation.

**Tertiary syphilis** is characterised by chronic superficial glossitis, and by the formation of gummata, which appear most commonly as hard globular masses in the median raphé and surrounding muscular substance. When these break down a deep excavation results with yellow-grey sloughs, and after healing a deeply-fissured tongue is left with perhaps a median gutter ; a chronic inflammation persists, which at any time may become malignant. A smooth atrophy, affecting especially the base of the tongue in front of the epiglottis, was recognised as a syphilitic lesion by Virchow. The diagnosis of syphilis may be confirmed by a positive reaction to the Wassermann test.

*Treatment.*—General anti-syphilitic treatment. Locally salvarsan (1 in 500) in glycerin may be painted on daily, but none must be swallowed. If salvarsan in addition to mercury fails to act, it clearly indicates that a patch, fissure, or induration of the tongue is becoming, or has already become, malignant. Excision of the patch should then be done without delay.

## Tuberculosis and Actinomycosis of the Tongue.

**Tuberculosis** generally affects the tongue in young adults already the subjects of pulmonary or laryngeal tuberculosis. A round or oval ulceration begins on the tip of the tongue, which is very painful. Other ulcers may appear around and coalesce with the first, forming an irregular excavation, with vertical or undermined edges, very slightly indurated, and a base uneven, covered with greyish sloughs or œdematous grey granulation, or a similar deep ulceration may occur at the base in front of the epiglottis. The ulceration progresses whilst the patient is dying.

Less commonly there appears a nodule on the tongue, which has been termed a *tuberculoma ;* it is most likely the result of direct inoculation of the tubercle bacillus, either on a lesion caused by a tooth, or it may have been carried in on a foreign body. This nodule enlarges and breaks down, caseous pus escapes, and an ulcer forms. Such a patient need not present any sign of pulmonary or laryngeal tuberculosis. The diagnosis may then be made directly by finding tubercle bacilli in the discharge from the nodule. Excluding syphilis, it is impossible to distinguish a nodule which has not yet broken down from actinomycosis.

*Lupus* starting about the nose and lips may be inoculated upon the tongue.

*Treatment.*—The ulceration of the tongue occurring in patients dying from general tuberculosis may be relieved by removing causes of oral sepsis, and extracting teeth, especially the lower incisors which come in contact with the

tip of the tongue. The ulcers should be gently cleaned by wiping them over with a camel's-hair brush or piece of soft gauze or silk soaked in permanganate or peroxide of hydrogen. After being cleaned and dried, orthoform may be dusted on the ulcer, or a powder containing iodoform (grs. iv ), morphin (gr. $\frac{1}{2}$), and starch.

**Actinomycosis,** when inoculated upon the tongue, appears as an indolent nodule. It has been occasioned by the penetration of a fragment of vegetable material, an awn of barley or grass whilst being held in the mouth, a grain of corn driven in from the drum of a threshing machine, etc. If there is no history of a lesion, and if no foreign body can be detected by the X-rays or by trans-illuminating the tongue, then excision offers the best method of both diagnosing the disease and curing the patient. If the nodule has reached the stage of breaking down, so that the small characteristic yellow bodies can be discovered in the pus, there is danger of extension. Such a nodule might disappear under large doses of iodide of potassium, and hence there is a possible source of confusion with a gumma. The histological examination after excision serves to distinguish it from a tuberculoma.

## The Base of the Tongue.

The *swelling of the circumvallate papillæ* induced by oral sepsis is referred to under *Chronic Glossitis ;* the *tumours and cysts at the foramen cæcum* under the Thyro-glossal section of the *Diseases of the Thyroid Gland. Smooth atrophy and gummatous ulceration* occur in syphilis and may induce an epithelioma. A *tuberculous ulceration* may complicate pulmonary and laryngeal tuberculosis.

The *lingual tonsil* consists of a collection of lymphoid tissue, covered by epidermis, which lines a number of small follicles. It is subject to follicular inflammation and hypertrophy, which may accompany that of the faucial and pharyngeal tonsils or exist separately, when attention may be drawn to it by a tickling cough, soreness, and muco-purulent expectoration. The diagnosis is made by the use of the laryngeal mirror.

*Treatment.*—Painting with iodine or nitrate of silver, in marked cases erasion.

## Benign New Growths of the Tongue.

A **papilloma** may arise as an enlargement of a fungiform papilla and appear as a more or less pedunculated tumour. It should be distinguished from a warty growth, the result of chronic superficial glossitis, because the latter will probably be a commencing epithelioma.

*Treatment.*—Under local anæsthesia a cut may be made through the mucous membrane round its base and the connective tissue pedicle ligatured ; the gap in the epithelium is closed by a suture.

A **fibroma** is a rare tumour which originates in the submucous connective tissue, grows very slowly, and is covered by normal epithelium. It forms a tough, softish, œdematous mass. It should be excised by cutting round its base.

A **lipoma,** also rare, is a soft lobulated tumour covered by thin epidermis, through which the yellow colour of the tumour is perceived. It may be circumscribed, when it can readily be shelled out ; but also it may be a diffuse growth among the muscles of the tongue, when it may well be left alone unless large enough to form a sort of lipomatous macroglossia.

**Venous angioma and lymphangioma** have been referred to under *Macroglossia.*

## Sarcoma of the Tongue.

As compared with epithelioma, sarcoma of the tongue is very rare indeed. One type, spindle-celled or round-celled in composition, has appeared as a steadily growing tumour in the muscular substance of the tongue, unattended by glandular enlargement. A gumma being excluded, if a fibro-sarcoma has grown slowly and if confirmed by microscopic examination, the tumour can be shelled out by dividing the mucous membrane. If, however, the tumour proves to be an oval or large round-celled sarcoma, the affected portion of the tongue should be freely excised.

A second type of sarcoma forms a pedunculated swelling projecting from the tongue, which tends to ulcerate on the surface. It should be excised by cutting widely round its base.

A third and more malignant type is a small round-celled sarcoma growing from the region of the lingual tonsil, and extending early to the glands in the neck. Such a sarcoma may supervene late upon a lymphangiectasis.

The term *endothelioma* has been recently used in two senses. Firstly, in accordance with one view taken of parotid tumours and applied to new growths at the base of the tongue of a slow-growing type of malignancy favourable for removal. Secondly, it has been applied to rapidly growing masses in which no nest cells are formed, but which are otherwise identical with very malignant types of epithelioma.

*Treatment.*—A free excision including the glands, as for epithelioma.

The prognosis after operation is no better than in the case of carcinoma, except that after two years it may be assumed with greater probability that the patient is cured. Of thirty-nine well-established cases of sarcoma only four were alive and well two years after removal.

## Cancer of the Tongue and Mouth: Squamous-celled Carcinoma, or Epithelioma.

Cancer arises on the tongue, floor of the mouth, or buccal aspect of the cheek generally from some pre-existing inflammation: firstly, from irritation by a tooth or ill-fitting tooth-plate; secondly, from irritation by tobacco, whether smoked or chewed, the latter in India, where the tobacco is mixed with betel nut and lime; and thirdly, from syphilis. These causes do not generally produce cancer before the age of forty, but if they do the cancer is very malignant. The use of tobacco explains the much greater frequency in men, but women who have smoked cigarettes have suffered from cancer. Untreated syphilis is of great importance in predisposing to cancer, and in favouring its rapid spread to the glands when once it has started. It is not so much the ignoring of obvious lesions as of the occurrence, almost unnoticed, of patches of leukoplakia and ulceration, traceable to some venereal lesion which was never marked enough to be well treated.

**The onset and extension of cancer.**—1. The cancerous change from a dental or syphilitic ulcer or fissure, or from a warty or smooth patch, is first shown clinically by a slight but increasing induration immediately underlying the ulcer or patch. This induration is seen under the microscope to be caused by a small-celled infiltration of the subepithelial connective tissue. At the same time the epithelial cells of the Malpighian layer show an increased but irregular mitosis, with the formation of keratin granules in the cells.

At this stage an excision of the ulcer or patch, along with the removal of the cause of the same, may be confidently anticipated to cure.

2. The formation of an ulcer with indurated and everted edges or of a marked warty mass, with an induration extending some way into the muscular substance of the tongue, is a clear sign that epithelioma has made some progress. Under the microscope the interpapillary processes of epithelium are found to have grown downwards, becoming first flask-shaped and then commencing to branch out. The cells of the growing margin in particular show irregular mitoses and keratin granules, whilst in the centre of the column the cells formed by this proliferation, after becoming flattened and keratinised, tend towards a concentric arrangement, and this concentric arrangement by further keratinisation and compression develops into typical cell-nests. But in a rapidly growing epithelioma the formation of cell-nests may be scanty, imperfect, or almost absent.

Deeper than the epithelial downgrowth the small-celled infiltration has now invaded the muscular substance, and chains of cells may be traced for some distance down between the muscle fibres and along the lines of the vessels and lymphatics.

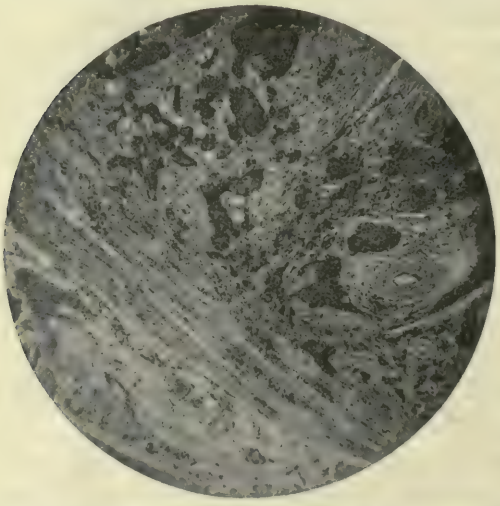


FIG. 288.—Deeper layer of a rapidly infiltrating epithelioma of the tongue. Epithelial cells are seen spreading along between muscle fibres, preceded by a small celled infiltration.

Although it may be impossible among this small-celled infiltration to distinguish small round cells of inflammatory origin from cells of epithelial origin, yet there is no doubt that some are cancer cells. Hence for practical purposes, especially when there has not existed an acute septic condition in the mouth, the small-celled infiltration must be regarded as indicating the actual extension of the cancer.

3. In the case of an early epithelioma as defined in the preceding paragraph, a careful histological examination of the lymphatic glands to which the lymphatics run from the affected area, especially the nearest ones, will show signs of vascular dilatation and small-celled infiltration. Clinical experience appears to justify the working hypothesis that this early small-celled infiltration of the nearest lymphatic glands includes cancer cells, but that at this stage no cancer cells need have become arrested in their course along the lymphatics, nor have gone further than the nearest lymphatic glands.

Hence at this stage a cure may be effected by removing the epitheliomatous ulcer or wart from the tongue so deeply and widely as to go beyond the range of small-celled infiltration, and then through an incision in the neck the nearest lymphatic glands may be dissected out freely, whilst the tissues through which the lymphatics run from the primary disease to the lymphatic glands may be preserved. In this way the patient may be cured at less risk and with a very limited amount of deformity.

4. The further stage in the extension of a squamous-celled carcinoma is marked by the invasion of the muscular substance of the tongue by the

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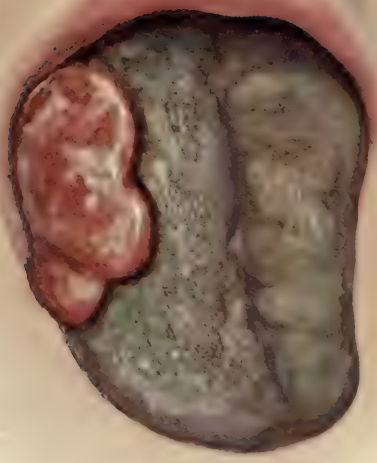


EPITHELIOMA OF THE TONGUE. (After the late Sir Henry Butlin, St. Bartholomew's Hospital Museum.)

A raised mass of new growth, ulcerated on the surface; the rest of the tongue is covered by a thick, green-black fur due to the foul condition of the mouth and the immobility of the tongue.

epithelial columns, which now break up, and prolongations run downwards in the intermuscular connective tissue preceded by a small-celled infiltration. Clinically this is marked by an induration deep in the muscular substance of the tongue, by a limitation of the movements of the tongue, and by a glandular enlargement. The nearest lymphatic glands are found actually infiltrated by epithelioma, or as a rather more favourable sign the gland is simply swollen by marked small-celled infiltration.

Experience now shows that at this stage, if the growth is well to one side, the opposite half of the tongue may be presumed to be unaffected; but when the growth has reached the middle line or has crossed it, even although it is only by small-celled infiltration, both halves of the tongue must be assumed to be infected. Even although limited to half the tongue, yet the disease must be presumed to have spread among the muscle fibres down to the hyoid bone. Moreover, by spreading along the lymphatic channels it has also formed islets of epitheliomatous infiltration in and behind the mylo-hyoid muscle, and in the submaxillary region. Whilst the nearest lymphatic glands are most infected, the cancerous infection has now extended to all the glands in the anterior carotid triangle.

From this argument of an infection in continuity of all the tissues between the primary growth and the lymphatic glands, the operation required to remove the disease must entail a removal of the primary disease and glands with the intervening tissues in one block.

**The lymphatic glands invaded by epithelioma of the tongue and mouth.**—In epithelioma of the frænum and anterior third of the tongue and floor of the mouth the *submental glands* are involved; from these lymphatic vessels pass both to the glands under the sterno-mastoid and to the lower deep cervical glands in front of the first part of the subclavian artery behind the clavicle. Hence actual infiltration of the submental glands by epithelioma suggests that at any rate the whole of the anterior triangle, perhaps on both sides, must be cleared; beyond this the case becomes incurable from infiltration in the root of the neck. In epithelioma of the middle and posterior part of the tongue and corresponding part of the floor of the mouth, the *submaxillary lymphatic glands* in the digastric triangle, including those lying within the capsule of the submaxillary salivary gland, are the first involved. From these lymphatics pass to the deep cervical glands. Behind the submaxillary salivary glands there is *lymphatic gland tissue in the septum* separating it from the *parotid*, also within the *capsule of the lower end of the parotid gland*. The upper part of the *chain of deep cervical glands* lies under the sterno-mastoid, from the mastoid process to where the anterior belly of the omo-hyoid crosses the large vessels, along the course of the internal jugular vein. The lymphatic vessels from the posterior third of the tongue pass direct into the deep cervical glands; the lymphatics from the cheek pass through the parotid lymphadenoid tissue to reach the deep cervical glands (see also Section VI.).

## Operations upon the Tongue.

1. **Excision of a superficial patch or ulcer.**—A patch or ulcer on the dorsum is excised by an elliptical incision, whilst if the tip or lateral margin is involved, the incision is V-shaped. In depth the excision should extend well into the muscular substance. The wound is sutured and the excised tissue submitted to microscopical examination.

2. **Excision of half the tongue.**—An incision having been made in the median raphé through the mucous membrane above and below, the separation of the

two halves is begun by a cut with scissors at the tip and the tongue split down the middle line by tearing. The half to be removed is then freed by dividing the anterior pillar of the fauces and the mucous membrane of the floor of the mouth, and drawn well forwards and upwards out of the mouth.

The genio-hyoglossus and the hyoglossus are divided with scissors from before backwards a safe distance away from their insertions into the under-surface and lateral margin respectively, and the lingual artery and its dorsalis linguæ branch, passing upwards to the tongue, secured when they are met with. The excision is completed by a transverse cut well behind the growth, and the raw surface left in the floor of the mouth covered in partially by freeing and suturing the mucous membrane.

3. **Excision of the whole tongue.**—The operation is carried out much as is described above, the preliminary splitting of the tongue being omitted. On its completion a ligature is passed through the stump and fixed to the outer aspect of the cheek with strapping, to prevent the remains of the tongue falling backwards and blocking the upper aperture of the larynx.

4. **The removal of the lymphatic glands from the carotid and digastric triangles.**—The operation area having been freely exposed by the reflection of two large triangular, superficial flaps of skin, all the fatty and lymphatic contents, including the submaxillary salivary gland, are removed in one piece. Great care should be exercised not to miss the suprahyoid gland. The operation includes the ligature of the common facial vein at its junction with the internal jugular, the facial artery where it enters the deep aspect of the submaxillary salivary gland, and the lingual at its origin from the external carotid.

The removal of glands and the excision of the tongue are best done at one sitting in this order. After the preliminary ligature of the facial and lingual arteries the ablation of the tongue is a simple matter, and does not occupy more than a few minutes. There are serious objections to performing the operation in two stages, whether the tongue or the glands are tackled first. In the former case septic absorption from the operation area in the mouth will render the glands more difficult to remove, and the patient, having been rid of all visible disease, may refuse a second operation. In the latter, time is allowed for further extension of the primary growth, with the added danger of carcinoma cells finding their way into the loose tissues of the neck through the divided lymphatic vessels.

In cases in which a very extensive intrabuccal operation is required and severe hæmorrhage anticipated, it may be advisable to perform a preliminary laryngotomy and plug the back of the buccal pharynx with a sponge. In old weakly people laryngotomy of itself may be followed by post-operative pneumonia, and thus defeat the very object for which it was performed.

5. **Dissection** *en bloc* **for the removal of carcinoma of the tongue.**—A *dissection en bloc* is necessary when a carcinoma has spread into the muscular substance of the tongue, for then it must be assumed that the disease has extended down the muscles towards the hyoid bone. Moreover, when the disease has involved the floor of the mouth, the fauces, and tonsil, it must be assumed that the mylo-hyoid and adjacent portion of the superior constrictor muscles are implicated.

This operation has the special danger of a communication of the mouth with the wound in the neck, tending to cause sepsis and possibly secondary hæmorrhage. The difficulty in swallowing when the mylo-hyoid is removed, especially when a partial excision of the lower jaw is added, promotes infective pneumonia and induces sudden heart failure. A *dissection en bloc* has its

limitations. When the lymphatic glands in the neck are already infiltrated by carcinoma, then, if they are closely adherent to the large blood-vessels, an operation is definitely contra-indicated. This is certainly the case if the operation entails ligature of the common or internal carotid. If it is necessary to excise a portion of the internal jugular vein, there must be a sound portion above and below, which can be secured by ligature. Even then it will be necessary to divide or excise the sterno-mastoid muscle and remove the glands from the posterior triangle down to the junction of the internal jugular and subclavian. In such a case a short incision is first made along the sterno-mastoid, and a careful exploration will then enable the surgeon to recognise an inoperable case before harm is done.

A **carcinoma of the frænum and tip of the tongue** which is adherent to the jaw should be removed, after a preliminary laryngotomy, by cutting through the lower jaw on each side in front of the masseter, and removing this portion together with the anterior half of the tongue. At a second operation the glands of the anterior triangle may be dissected out on each side. A cast of the jaw should be taken beforehand and a denture made, the latter being fixed in position by a dentist at the time of the operation.

**Division of the jaw.**—When *the horizontal ramus and angle are involved* it is better to divide the jaw about the canine tooth and then disarticulate, including the masseter and internal pterygoid muscles in the removal.

### Treatment after Operation.

The laryngotomy tube, if it has been inserted, is dispensed with before the patient leaves the table. At the end of the operation the patient should be turned three parts over on to the face with the head low, and then all blood and mucus runs out of the angle of the mouth on to a pad. The nurse has simply to wipe away mucus and blood from between the lips ; there will be no occasion to sponge out the pharynx, which is a cause of pain and retching and is liable to set up recurrent hæmorrhage. As soon as he is able, the patient can rinse out his mouth with permanganate solution at frequent intervals. He is at first given rectal salines, but is soon able to take liquids from a feeder through a rubber tube on the end of the spout. If not, a catheter may be passed through the nose, or an œsophageal tube through the mouth.

It is less satisfactory to keep a tube in the œsophagus, for ulceration outwards into the carotid has occurred, and this has been an even more frequent accident when the end of the tube has been brought out through the wound in the neck. For the most difficult cases by far the best method of feeding is by a temporary gastrostomy, for the wound in the neck can then be kept unsoiled by food.

### Prognosis after Operation.

1. The removal of a patch or superficial ulcer is attended by no danger, and if it is found on microscopical examination that epithelioma has not begun, the patient can be reassured, and he will recover without any persistent deformity. He will remain free from further disease unless the cause continues and produces fresh patches, when the operation may have to be repeated. Regarding this stage as really precancerous, the procedure may be declared an entirely successful one.

2. When an indurated patch or ulcer is found on microscopical examination to be already epitheliomatous, the surgeon should proceed at once to the dissection of the anterior triangle. No important danger is incurred, and a

considerable proportion of these patients are cured. The best results hitherto were obtained by Butlin, largely from patients of this class ; more than 30 per cent. were alive and well three years after operation. Failures are due—firstly, to a widespread diffusion occurring in the earliest stage of the cancer ; secondly, to a crossed infection, which, whenever the disease lies close to or across the middle line, should be anticipated by a dissection of the second anterior triangle ; thirdly, the infection may have already spread to the posterior triangle of the neck, when an additional dissection may arrest the disease ; fourthly, the causes producing epithelioma continuing, there may be a further development in the remaining part of the tongue.

3. The larger operations are indicated when the disease can be removed by cutting through apparently sound tissue.

The mortality is high, varying with the extent of the operation and the patient's condition. The causes of death which cannot be prevented are those chiefly due to age or syphilis or both, and the effect which these have had on the patient's heart and blood-vessels. Ten days or more after the operation, before which date the patient has been in a fair way to recover, cerebral thrombosis or hæmorrhage, heart failure, or a sudden onset of broncho-pneumonia may cause the patient's death. Further, the disease tends to reappear beyond the area of removal, whether in the tongue or neck, in the majority of cases within one or two years, but the three years' limit is no real milestone marking safety. Once epithelioma has started, there is no limit to the liability to late recurrence, which may supervene twenty or more years after operation. Excision in the precancerous stage is free from this cause of anxiety.

### Palliative Treatment of Cancer of the Tongue.

When the disease has become inoperable the greatest amount of relief that can be obtained is got by reducing septic decomposition on the ulcerating surface. This should be painted over several times a day with mercury bicyanide (1 in 1,000) or permanganate of potash (1 in 400) and the mouth rinsed out every hour or two with permanganate or peroxide of hydrogen lotion. All teeth irritating the growth, decayed or sound ones, should be extracted. The stretching or dividing of the lingual nerve does little or no good, for the glosso-pharyngeal territory is invaded, and this occasions earache. Cocain, morphin, or menthol applied locally has usually but little value. The patient's remaining span of life can only be rendered bearable by increasing internal doses of opium and morphin, supplemented by aspirin or phenacetin when the pain is most acute.

**Relief in inoperable cases.**—With this object the following measures have been recently adopted :—

1. *Diathermy.*—This method is an exceedingly valuable one when applied to the treatment of inoperable fungating carcinoma of the tongue. Complete dry necrosis of a foul, bleeding mass can be secured, and the mass of dead tissue then removed with the diathermy knife. In many cases the resulting wound heals well and forms, for a time at least, a sound scar, with the greatest possible relief of pain, sepsis, and hæmorrhage.

2. *X-rays.*—As now used from a distance, little or no effect can be anticipated. If too intense, a burn on the surface and rapid enlargement of the glands in the neck have followed.

3. *Radium emanations in a tube.*—If the tube is placed in contact with the growth, there is a local destructive influence, but there is an equally destructive effect upon the healthy tissues within the radius of the tube. If the tube

is inserted into the middle of the growth, there is a local necrosis varying in extent, and it has been hoped that thereby an antitoxin might be produced which, being absorbed, might check or arrest metastatic growths. This has not yet happened in squamous-celled carcinoma; on the other hand, great pain has followed, and at the moment the use of radium seems contra-indicated. There is a tendency for the disease to become widely diffused in the neck, and indeed its use has been followed by the appearance of multiple secondary growths in distant parts, such as the skin.

## Diseases of the Palate.

### Inflammation of the Soft Palate.

**Inflammation of the uvula.**—Uvulitis accompanies inflammation of the fauces and pharynx. The uvula becomes red, œdematous, and painful; with a continuance of the inflammation it undergoes chronic enlargement and elongation. It may come into contact with the base of the tongue, epiglottis, and rima glottidis, and so produce a troublesome tickling cough.

*Treatment.*—In acute inflammation scarification may be practised; in chronic inflammation astringents are applied. If the elongation persists a part of the uvula may be amputated; more than this must not be removed or the singing voice, in particular, may be affected.

**Syphilis of the soft palate.**—The uvula, or part or the whole of the soft palate, may be destroyed by syphilitic ulceration, whether congenital or acquired. The process may be rapid, or there is a slowly progressive serpiginous ulceration. The voice takes on a nasal twang; food may pass back into the nose. Later there is much fibrous scarring, and this is worse when the naso-pharynx has been simultaneously attacked. The communication with the nose may be reduced to a narrow channel, or be quite shut off.

The worst cases suffer from retention of mucus at the back of the nose, and from closure of the Eustachian tubes, the latter resulting in deafness and mastoid pain owing to the retention of mucus in the middle ear and antrum, upon which otitis may supervene.

*Treatment.*—Active mercurial treatment, supplemented by salvarsan. The adherent soft palate may be separated from the back wall of the naso-pharynx; see p. 658.

**Ulceration of the soft palate** may also be due to tuberculosis, or to sloughing following diphtheria and scarlet fever, or to epithelioma.

### Inflammation of the Hard Palate.

**Periostitis and abscess** close to the alveolar border are dental in origin. An incision should be made through the muco-periosteum at once and the offending tooth removed to prevent necrosis.

**Syphilitic periostitis, gummatous ulceration, and necrosis** occur in the middle line, either along with destruction of the soft palate or in front of the latter when a perforation occurs very quickly. In very severe cases the hard and soft palate and the septum of the nose, even the alveolar portions of the upper jaws, may be destroyed. The process is similar whether congenital or acquired in origin.

In the later states of syphilis accompanying locomotor ataxia a *perforating ulceration* of the palate and gums and quiet necrosis of the alveolar border may open up a communication with the antrum.

*Treatment.*—Mercurial treatment on the first signs of periostitis. It often proves insufficient, and salvarsan should be given also.

After the disease has been arrested it may be possible to close a small hole by a plastic operation. In extensive cases the gap is covered in by an obturator.

**Tuberculous ulceration and caries** of the hard palate may complicate pulmonary tuberculosis; in young people it may have the characteristics of lupus.

## New Growths of the Palate.

Tumours must be distinguished from periostitis of dental or syphilitic origin referred to above; also there are congenital irregularities and ridges along the middle line, the *torus palatinus*, etc.

An *endothelioma of the palate* forms a smooth, rounded elastic swelling covered by intact mucous membrane; it can be shelled out and may not recur.

Another type of endothelioma, perithelioma, or large-celled sarcoma, arising on the soft palate of young people, is very malignant. Vascular tumours have been met with, such as a *fibro-angiosarcoma*, requiring removal of part of the upper jaw.

*Melanotic sarcoma of the palate* has been noted many times, always being very malignant and inoperable.

*Papilloma* has been generally seen on the soft palate, and the question then arises whether it is a simple growth or really the projecting part of an epithelioma.

*Epithelioma* may arise from the same causes as on the tongue; to anticipate this all suspicious patches and ulcers should be excised early so as to avoid removal of the upper jaw.

## Diseases of the Gums.

**Spongy and bleeding gums** occur in scurvy, mercurial poisoning, and leucocythæmia.

**Hypertrophy of the gums** is commonly due to dental disease. When localised round a carious tooth and pedunculated it is called a *polypus;* when lobulated a *papilloma*, or more generally an *epulis*. The treatment is then the removal of the tooth and the snipping off of the overgrowth.

But there also occurs a general hypertrophy of the gum, which has been considered a *congenital hypertrophy*, although it may be noticed only at the first dentition, and may possibly be a manifestation of scurvy or of an early alveolar infection. The appearance presented is that of an overcrowded row of teeth fringed by a lobulated overgrowth of the gums, which so surround the teeth that they appear to be buried in it. It is necessary to shave off not only the hypertrophied gum, but the portion of the alveolar border from which it grows, otherwise there is recurrence.

**Atrophy of the gum** is a senile change, which is also marked in some cases of locomotor ataxia, and especially accompanies pyorrhœa alveolaris.

**Epulis.**—The term *epulis* is a clinical one, and denotes a pedunculated or semi-pedunculated small red tumour growing from the periodontal membrane of a tooth socket, usually in the incisor region. Epulis may be classified into false and true. The former is a granuloma produced by the irritation of a dead tooth; the latter is a true new growth, and on section may prove to be a fibro-sarcoma containing giant (myeloid) cells, a simple fibro-sarcoma, a fibroma, or rarely a squamous-celled carcinoma. The so-called *myeloid epulis* is

recognised as a steadily growing, purplish red, vascular swelling of a spongy consistence which, when injured by the teeth, ulcerates and bleeds freely.

An *epitheliomatous epulis*, when it extends to the jaw, may be mistaken for caries and necrosis; when it has spread to the antrum it simulates the cancer of the upper jaw referred to on p. 670.

*Treatment.*—False epulis is treated by removal of the granuloma and offending tooth, together with thorough scraping out of the interior of the tooth socket. A true epulis usually requires removal of a segment of the bony alveolus in addition. In more malignant cases the treatment is similar to that of tumour of the jaw.

## Diseases of the Salivary Glands.

**Ptyalism, or salivation.**—This means such an excessive secretion of saliva that it escapes from the mouth or has to be swallowed by special effort. The cause may lie in the *central* nervous system; it is met with in general paralysis of the insane, bulbar paralysis, hemiplegia, hydrophobia, melancholia, and in pregnancy.

*Reflex salivation* is set up by dentition, tic-douloureux, and earache through the chorda tympani, also by drugs such as ether.

*Direct excitation of the salivary gland* by mercury, as shown by experiments on cats, is the mechanism producing mercurial salivation. Formerly mercury was given in excess; the glands swelled, and pints of saliva were secreted in a day. The mercury excreted attacks the gums, especially of the lower jaw, causing swelling, bleeding, ulceration, and gangrene, followed by necrosis of the bone; diarrhœa may exhaust the patient and lead to death. Now, mercurialism may occur from contact with mercury in the course of work, or because of some special susceptibility to small doses. The treatment after stopping its administration consists in giving opium and the frequent washing out of the mouth with permanganate of potash.

**Xerostoma, or dry mouth.**—A diminished secretion of saliva from the parotids in cases of chronic parotitis is the common cause of dry mouth. Such a parotitis may be set up by extension from a mouth rendered foul by pyorrhœa alveolaris. It has been seen especially in women with teeth carious and crumbling away; the lips become dry and scaly, the tongue fissured like crocodile's skin, the cheeks and gums glazed and covered by crusts. The parotid glands are swollen and tender. The disease has been termed nervous in origin, but there does not seem much ground for this view. The worst cases have been women about fifty, and, in addition to the signs above noted, they have had a dry, harsh skin, dryness of the conjunctiva and nose, a loss of taste, and subjective sensations of bitterness or saltness. Such symptoms may be referred to a toxic impairment of nutrition, the whole originating in the dental disease.

*Treatment.*—By far the most important thing is to get rid of the teeth, and as soon as healing has occurred the fitting in of dentures, so that the patient can masticate properly.

**Parotitis.—Acute infective parotitis, or mumps,** causes fever, pain, swelling, and difficulty in moving the jaw, but there is an absence of superficial redness or brawniness, such as indicates suppuration. Difficulties of diagnosis in anomalous cases may bring them under the notice of the surgeon. The inflammatory swelling of the parotid is not symmetrical, or affects one side before the other; or it is chiefly the submaxillary, sublingual, or lachrymal

glands which swell; or with only slight swelling of the parotid, so slight as to be overlooked, a young man suffers from acute orchitis with a slight mucous discharge from the urethra. The orchitis is generally unilateral, and is accompanied by pain and even delirium; exceptionally it is bilateral, the pain and delirium severe. In the latter case there may occur a parenchymatous degeneration of the tubules of the testes, the typical epithelium changing into irregularly cubical cells which afterwards disappear. The tubules are reduced to cords formed by thickening of the basement membrane and of the peritubular fibro-elastic tissue. But, as there is little interstitial fibrosis, the testes do not become much smaller nor harder than normal. Yet the patient is rendered sterile, as may be confirmed by noting an absence of spermatozoa. In the female there are corresponding complications—ovaritis, vulvo-vaginitis, œdema of the labia, and mastitis—but they are not severe. Moreover, acute abdominal pain felt just above the umbilicus has occurred and is attributable to pancreatitis; the pancreatitis is neither severe nor lasting; fat has been noted in the fæces, but not sugar in the urine.

The delirium in a young man may supervene rapidly and become maniacal; it has been followed in some children by death. There are nerve disturbances, generally temporary, exceptionally permanent; facial paralysis; tinnitus and vomiting; exceptionally labyrinthine deafness; papillœdema; even optic atrophy. Another complication is thrombosis in a femoral vein.

Severe cases of mumps may be complicated by temporary facial paralysis, tinnitus, and vomiting, and even by meningitis.

**Acute suppurative parotitis** has its origin in oral sepsis. As compared with its incidence formerly, it is now very rare. When the mouths of exhausted and septic patients were not kept clean, suppurative parotitis was a common complication of fevers—typhus, typhoid, etc. In surgical practice it complicated septic cases, whether pelvic, genito-urinary, puerperal, or pyæmic. In all these, and also in cases of senile exhaustion, etc., in which an edentulous mouth is kept open, the lips, mouth, teeth, and pharynx soon get covered with dry, sticky crusts. It may complicate thrush in the mouths of neglected infants. In them one or both parotids become tender, red on the surface, brawny, and the general condition of the patient is a very grave one; the child may relapse into the so-called typhoid state and die.

*Treatment.*—Punctures or short incisions should be made into brawny points, even before suppuration has set in. The incisions should be in front of the posterior border of the vertical ramus of the lower jaw, so as to avoid wounding the external carotid and superficial temporal arteries; the incisions should be horizontal, so as not to divide facial nerve fibres.

**Chronic parotitis.**—The general cause is oral sepsis, due to neglect of carious teeth and pyorrhœa alveolaris. Intoxication by lead, copper, and iodide of potassium predisposes to oral sepsis by causing a diminution in the saliva secreted. The condition of xerostoma, or dry mouth, has been referred to above. By glass-blowing and trumpet-playing the ducts may become dilated, giving an opportunity for infection to ascend. Exposure to X-rays causes the gland to swell owing to the arrest of secretion.

*Treatment.*—Extraction of teeth and the removal of oral sepsis; hot fomentations to the gland, which is afterwards gently massaged.

*Parotid calculus.*—This is much less common than submaxillary calculus, and is a complication of chronic parotitis. It forms a tender swelling in the line of the parotid duct, and may be detected by probing the duct and by X-rays.

***Treatment.***—Remove by slitting up the duct from the mouth.

*Parotid cyst.*—A fluid swelling may arise from obstruction of the main or one of the secondary ducts, and on rupturing a fistula is produced.

*Parotid fistula.*—A fistula is generally due to a wound dividing the duct, but may also follow upon suppuration round a calculus, from the rupture of a cyst, or the breaking down of a tuberculous gland. Saliva escapes on the cheek, especially during mastication.

*Treatment.*—Pass a fine probe-pointed director up Stenson's duct and slit up the duct into the mouth, if possible, beyond the point where the fistula opens upon the cheek. Then the fistula is pared, the mucous membrane turned inwards and sutured, and the skin outwards.

**Parotid lymphatic gland swellings.**—A pre-auricular lymphatic gland is superficial to the capsule of the parotid, or lymphatic gland masses may lie within the capsule. They become swollen in cases of parasitic inflammation of the scalp, and inflammation of the eyelids or conjunctiva. The inflammation may be simple, or it may be tuberculous. If a tuberculous gland within the capsule breaks down a salivary fistula may be set up.

*Treatment.*—Excision through a horizontal incision, the facial nerve fibres being retracted.

**Ranula.**—This is a term which should be limited to cysts of the mucous salivary glands in the mouth.

1. A sublingual ranula, the typical "ranula," is generally seen in a child. Its origin has been the subject of much controversy, but it is probably due to a congenital malformation causing an occlusion of one or more of the ducts of the sublingual gland, resulting in a cystic degeneration of the gland itself. It appears as a bluish white, semi-translucent, globular or ovoid cyst, situated to one side of the anterior part of the floor of the mouth, and contains glairy saliva. It may be distinguished from a submaxillary ranula by the absence of pain in mastication and by the patency of Wharton's duct, along which a fine probe can be passed (see Plate 13 B).

The proper treatment is excision from within the mouth. The cyst is incised, and after the contents have escaped the interior is filled with cotton wool, by which the thin cyst wall and any cystic remains of the sublingual gland may be recognised and removed.

2. *Submaxillary ranula* is generally seen in an adult, and is a true retention cyst caused by obstruction to Wharton's duct, whether by a fine fruit seed or by inflammation secondary to dental irritation and the formation of a salivary calculus. The cyst forms a cylindrical swelling in the line of Wharton's duct, and the retention of saliva causes pain on mastication, which may be so severe as to stop eating. The patency or obstruction of a Wharton's duct may be distinguished by observing whether there is or is not a flow of saliva from the papilla when the tongue is quickly curled up to the roof of the mouth, or when the patient inhales a whiff of ether or a savoury odour. Saliva may be pressed out, or a probe passed along a patent duct.

More rarely the duct is obstructed near its commencement; then the portion of the gland lying external to the mylo-hyoid is distended, and a painful swelling is felt below the angle of the jaw.

A **salivary calculus** is the result of obstruction to the flow of saliva, and it usually forms in the main Wharton's duct, but may do so in the secondary ducts of the extrabuccal portion of the gland. The calculi are composed of carbonate and phosphate of lime deposited in inspissated mucus. The calculus in Wharton's duct has the shape of a date-stone, or, if larger, of an almond, and is detected as a hard body in the line of the duct, which may be touched by a needle and can be recognised in a radiograph. It gives rise to pain, swelling,

and tenderness in the gland; if neglected, suppuration may be set up and a salivary fistula form under the jaw. When the calculus becomes surrounded by inflammatory tissue it may give rise to the suspicion of cancer.

The calculus is removed by slitting up the duct, or if the duct is thickened it may be excised with the calculus through the mouth. When the extrabuccal portion of the gland is affected by chronic inflammation small calculi like rice grains may be intermittently discharged, and the increasing size of the indurated gland round the calculus forms a hard mass. Then a submaxillary excision of the whole gland is indicated.

*Rare forms of ranula* are :—

(*a*) A cyst in the glands of Blandin or Nuhn, which lie one on either side beneath the tip of the tongue. When the tongue is protruded, it carries out the cyst with it.

(*b*) A cyst in the incisive glands, small racemose glands lying one on each side of the junction of the frænum linguæ with the inner aspect of the lower jaw, the ducts opening near the roots of the incisor teeth. The cysts contain glairy mucus, not serous fluid.

**Dermoid cysts of the floor of the mouth.**—See p. 699.

Fig. 289.—Parotid tumour.

### Tumours of the Parotid.

**Mixed parotid tumours.**—The parotid tumour *par excellence* commences as a benign new growth, and usually, whilst growing slowly to a large size, remains innocent over a period of years. It may then undergo a rapid malignant development. It generally arises in the superficial part of the gland in front of the auditory meatus. The tumour is encapsuled within the gland substance, the rest of the parotid being pushed aside and atrophied. The skin is thinned out over the tumour, which whilst small is freely movable in the parotid gland; the facial nerve fibres are spread out over the tumour without paralysis being caused. The swelling has at first a smooth outline; as it grows the outline becomes irregular, nodular, or some of the projections become cystic.

In its early stages a short incision is made horizontally over the tumour, the fibres of the facial nerve separated, the capsule of the parotid divided, and the tumour shelled out; healing then follows without a parotid fistula, there is no facial paralysis, and the tumour does not recur.

When such a tumour is cut across, to the naked eye the structure appears of a mixed character, fibrous, glandular, cartilaginous, cystic, nævoid, with variations. Hence the best name at present is *the mixed parotid tumour*. The microscopic examination of such tumours entirely confirms their mixed structure.

Two explanations of their origin have been put forward :—

1. That the tumour is an endothelioma arising from the endothelium of lymphatics and capillaries. Comparisons have been drawn between these parotid tumours and new growths arising on serous surfaces and from lymphatics and capillaries elsewhere. It is explained that to form the mixed structure the endothelium of lymphatic vessels fills the lumen and lymphatic spaces with a hyaline substance, which has a tubular arrangement, differing from cartilage in its micro-chemical reactions. Some of the endothelial cells may develop the fibrous tissue ; others undergo mucoid degeneration. From the endothelium of capillaries may arise nævoid or angiomatous portions of the tumour.

2. That the parotid tumour is an overgrowth of embryonic *rests*, of both epithelial and mesoblastic origin—a mixed adeno-chondro-myxomatous, embryogenous tumour.

In the embryo during the eighth to the fifteenth week of fœtal life the salivary glands are developed by outgrowths of epithelium from the first branchial cleft, in close connexion with the periosteum and Meckel's cartilage forming the mandible. It is therefore possible that the epithelial outgrowth forming the parotid gland may include epithelial and connective tissue elements or *rests*. As distinguished from endothelial cells, the finding of prickle cells and of an intercellular secretion has been held to prove an epithelial origin ; and, holding the chondromatous material to be real cartilage, its occurrence can hardly be explained except from mesoblastic *rests*.

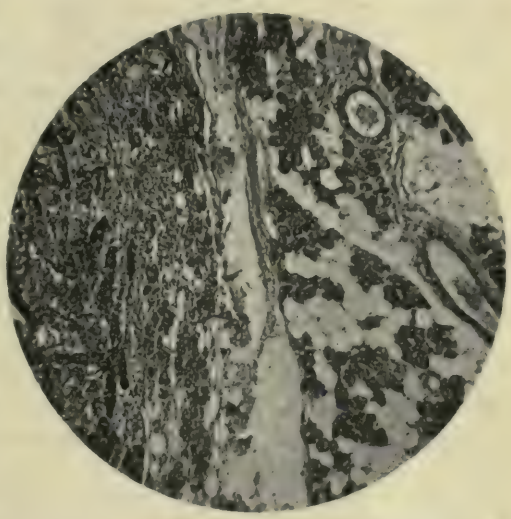


FIG. 290.—Carcinoma of the parotid (left half of figure right half) normal parotid gland of aged patient.

**Malignant tumours** are rarer than the mixed parotid tumour, upon which they sometimes supervene ; in other cases no benign tumour has been noticed beforehand. In young people a malignant tumour will probably be a sarcoma, in older people a carcinoma.

A malignant tumour grows rapidly and infiltrates the glands in the neck, superficial and deep, at an early stage. Although it may appear to begin in the superficial portion of the gland, the deep part is also involved. The swelling is ill defined, the skin adherent, later purplish, brawny, and finally ulcerated ; the facial nerve is infiltrated, and so paresis or complete paralysis is an early sign. The texture of the growth varies between a dense scirrhus and extreme vascularity ; the outline may be irregular with nodular bosses or bulging cysts. The disease is practically inoperable. A few cases have been treated by attempts to remove the whole gland and the lymphatic glands in the neck with ligature of the external carotid artery and removal of the facial nerve. But the facial paralysis, and the deep infiltration of the neck and base of the skull which follows the operation, prevent the patient from receiving even temporary relief from it.

**Symmetrical swelling of the salivary and lachrymal glands : Mikulicz's diseases.**—The condition as originally described by Mikulicz consists of a symmetrical, slow, painless enlargement of the lachrymal and salivary glands, the parotid being the salivary gland most commonly affected. The swellings are smooth and firm, and are not adherent to the skin or deeper structures. The condition is now recognised to be a syndrome which may be found in a variety of diseases ; some cases, at least, show the blood changes of lymphatic leukæmia with splenic and glandular enlargements, a few seem to be tuberculous, and some are suspected of syphilis.

The cases without blood changes, splenic and glandular enlargements, tend to recover spontaneously in two to five years ; the acute lymphatic leukæmias are necessarily fatal within a period of months.

**Submaxillary and sublingual salivary gland tumours** are similar to those of the parotid gland, but are much rarer.

*Treatment.*—Excision.

## Surgery of the Neck.

[For injuries of the neck, see Section XV., p. 746.]

### Inflammation, Suppuration, and Abscess in the Neck.

**Acute lymphadenitis without suppuration,** as described by Dr. Dawson Williams, is due to some infection, occurring doubtless through the mouth, which has not yet been identified. From the surgical standpoint it is necessary to distinguish this affection from those causing suppuration. After a period of incubation for about a week, as indicated by malaise or actual fever, the deep cervical glands along the anterior border of the sterno-mastoid become swollen, and the swelling after reaching its maximum in two or three days begins to subside spontaneously. The swelling more often begins on the left side, and the right follows ; it attacks young children, generally one after the other, in the same household. Whilst other signs of febrile disturbance are present, there is an absence of inflammation in the mouth, fauces, and pharynx, and no rash appears. Other glands—posterior cervical, axillary, inguinal, and mesenteric—also the spleen, may swell. But all subside without suppuration, leaving the child anæmic and weak. They are to be distinguished from the glandular enlargements met with in measles, scarlet fever, and diphtheria.

Some similar acute inflammation in adults may be due to pneumococcal and allied infections, the acute swellings subsiding without suppuration.

**Infective lymphadenitis followed by suppuration,** set up by staphylococci or streptococci, shows various degrees of virulence, from the most acute to that of the chronic induration attended by late suppuration, which especially complicates tuberculous lymphadenitis.

**Acute phlegmonous inflammation of the neck,** the so-called **Ludwig's angina,** is due to a streptococcal infection starting from diseased teeth, necrosis of the jaw, the tongue, tonsils, fauces, or larynx, and may complicate scarlet fever, measles, or diphtheria. From the site of inoculation a great congestion and œdema spread to the substance of the tongue, the wall of the fauces or pharynx, the lymphatic glands and connective tissue of the neck, and the œdema spreads rapidly in the planes of the deep cervical fascia.

The neck presents a dusky redness, a board-like or brawny œdema, whilst the patient suffers from acute septic intoxication. Suppuration follows in the œdematous tissues ; the infection spreads to the mediastinum, setting up pneumonia, pleurisy, or pericarditis. Death may ensue very quickly from œdema glottidis and heart failure, when the cardiac muscle may be found to

have undergone infective invasion. The internal jugular vein may be thrombosed, and on the clot breaking down septicæmia and pyæmia follow. The internal carotid artery may be invaded, causing death by hæmorrhage.

*Treatment.*—Administration of streptococcal antitoxin, short incisions into the brawny œdema and thrusting in blunt forceps whilst aiming to avoid important structures; laryngotomy or tracheotomy for dyspnœa; ligature of the carotid artery for hæmorrhage, but this can very rarely be done successfully.

**Subacute lymphadenitis followed by suppuration** is set up by invasion of staphylococci from carious teeth, suppurating tonsillar crypts, pediculi capitis, or infections about the mouth, nose, eyelids, external and middle ear. Incisions should be made in the lines of the folds of the skin, avoiding important structures, down to inflamed glands, before the suppuration has extended outside the gland capsules. Then an inflamed gland can be removed, the cavity lightly plugged, and fomentations put on outside. In addition the primary focus requires treatment.

**Tuberculous lymphadenitis.**—The invasion of the glands in the neck through the mouth often occurs without any obvious primary lesions. In other cases it is through a carious tooth, an ulceration of the gums, or an inflamed tonsil, that the tubercle bacillus invades the glands, or indeed from the skin of the face or scalp. The lymphatic glands are first infiltrated with small round cells, and then non-vascular areas of tuberculous foci exhibiting giant cells, lymphoid corpuscles, and tubercle bacilli are found, in which caseation and later suppuration generally occur. At the same time inflammation spreads into the tissues around and first mats the glands together; then suppuration spreads outside the glands.

Instead of suppurating, the glands may shrink by the formation of fibrous tissue enclosing caseous foci, or undergo further shrinkage still by fatty degeneration, or late suppuration may supervene.

In a few instances a marked but indolent enlargement, with prolonged absence of any tendency to suppuration, causes a gland to resemble in appearance and on section that of a young potato. On microscopic examination there is little appearance of any formation of tubercles, but rather that of a general infiltration, largely by endothelial cells. It is then difficult to distinguish this type from lymphadenoma, unless by animal inoculation, for tubercle bacilli are few in number.

In tuberculous adenitis the glands enlarge slowly with little or no pain; at first discrete and movable, they later coalesce and form both superficial and deep adhesions. After a time the glands tend to soften in the centre; the skin after adhering becomes reddened, then gives way, and curdy pus escapes. In the floor of an ulcer thus formed appears a portion of caseating gland material; the edges of such an ulcer are bluish pink and undermined.

Concomitant signs of tubercle elsewhere may be found, but are often absent. Also it is only in rare instances that such cases terminate by the dissemination of tubercle.

*Treatment.*—It is difficult to decide in a case of tuberculous lymphadenitis whether the glandular swellings will subside under general treatment or will suppurate, and as to surgical treatment, whether this should be limited or radical in character. In an early case, after treating the lesion which has probably favoured the entry of the tubercle bacilli, the patient should be well fed and given a course of several months or longer by the seaside or in the country. The local treatment which is certainly of value is direct sunlight; other light rays have not done good except for ulceration around a sinus,

and radium emanations for hypertrophied scars. Drugs which have been employed, whether topical or general, such as cod-liver oil, iron, or iodide, are hardly worth using. There are nicer and less expensive fatty foods than cod-liver oil.

Surgical treatment is required if there is threatened suppuration, or if there is a persistent indurated mass in which caseation is in progress.

Suppuration in a superficial gland is treated by making a short incision over it, incising and stretching open its capsule, then shelling it out and filling with iodoform gauze. After a day or so the skin is drawn together. In doing this one must not be tempted to go deeper, both on account of the danger of spreading the suppuration and of damaging a large vein through a small incision.

For the removal of all deeply-situated glands a free incision is a necessary preliminary, to be followed by a careful dissection ; the removal of only superficial glands through short incisions is generally followed by relapses and further operations.

The incision recommended and described below is, when carried out to its fullest extent, the Z-shaped incision of Senn. The other forms of incision adopted by many surgeons are the long and horizontal ones in the lines of the folds of the neck, extending behind and in front across the sterno-mastoid ; while a second one may be made below and parallel with the first.

The Z-shaped incision is made in part, or wholly, according as the posterior cervical, deep cervical, supraclavicular, or submaxillary glands are alone or all together affected.

This incision commences below and a little to one side of the chin, is carried across below the jaw and the mastoid process to the posterior border of the sterno-mastoid close to its insertion ; thence the incision is continued down the posterior border of the sterno-mastoid nearly to the clavicle, and finally turns across the supraclavicular fossa to end over the trapezius. The skin is raised by turning one flap forwards and downwards, the other backwards and upwards. Under one flap lies the anterior, under the other the posterior, triangle of the neck. With this good exposure and a careful dissection no danger to important structures should be incurred. Whilst adopting the precautions noted for the removal of malignant glands on p. 684, in the case of the tuberculous glands there is no occasion to dissect too close to important structures like the internal jugular vein, but rather, after exposing the mass adherent to the vein, to cut through the capsule and shell out the enlarged and suppurating glands.

On the other hand, when a clean dissection can be made without undue risk, healing by first intention and a favourable scar should be the objects aimed at. In the submaxillary region one should retract the subcutaneous tissue and platysma upwards, so as to avoid injury to the cervical branch of the facial nerve and thus preserve the nerve supply to the angle of the mouth. The sterno-mastoid muscle may be retracted forwards or backwards for the removal of the glands, but injury to the spinal accessory, hypoglossal, and vagus nerves must be avoided. Only exceptionally in late cases, when the sterno-mastoid has been infiltrated, does that muscle need to be divided or excised. To repeat, the internal jugular vein should not be injured or excised if it can possibly be avoided ; it involves an unnecessary risk both of an extending thrombosis, and of secondary hæmorrhage.

After arresting all hæmorrhage by ligatures or sutures, the skin is united with a drain at the posterior angles, and healing by first intention with a scar lying largely in shadow should result.

Exceptionally, when there is much suppuration the wound is filled with gauze and sutured later.

**Syphilitic lymphadenitis.**—The glands receiving lymphatics from the area of an extragenital chancre on the lip, tongue, cheek, or eyelid undergo very marked enlargement, rapid but painless in its occurrence, the mass feeling hard. This is practically always followed by a syphilitic rash, and therefore the only reason why a diagnosis fails to be made is the unsuspected character of the disease. A general enlargement of the glands, symmetrical in character, especially affecting the glands at the back of the head, is of common occurrence in secondary syphilis, and the diagnosis is easily made by concomitant indications.

In the tertiary period a mass of glands may be found of a hard fibrous texture, tending to break down into a gumma. This is the more easily diagnosed when it is a persistence of the enlargement occurring during the secondary stage. But when a unilateral mass is met with the cause may be overlooked.

**Actinomycosis, including other varieties of streptothrix infection.**—This infection has to be distinguished from chronic suppuration caused by staphylococci, from tuberculosis, syphilis, and malignant disease. It is characterised by starting generally around the lower jaw, less often in connexion with the fauces and tonsils; in addition to more or less deep inflammation, it early infiltrates the skin with a nodular induration. The nodules become reddish, soften, and form sinuses tracking amongst tough inflammatory tissue. The sinuses have a bluish margin and are lined by vascular granulations. The diagnosis is made by noting fishroe-like granules, yellowish or whitish, in the discharge, which, being stained by Gram's method, are found to consist of balls of mycelium.

*Treatment.*—If localised, the mass should be excised along with the enlarged glands, as in the case of tubercle. Failing this, all sinuses should be thoroughly opened up and scraped out. Large doses of iodide of potassium internally. Injections of formalin solution (4 per cent.), about ʒj. at a time, into or around the margin, may be tried, and the injections repeated after the reactionary inflammation has subsided.

**Lymphadenoma of the cervical glands.**—Lymphadenoma is suspected to be due to organisms absorbed from some source of irritation, and whilst in many cases this is mere surmise, in others a local lesion in the conjunctiva, nasopharynx, mouth, or larynx is traced.

Lymphadenoma commonly arises in the glands of the posterior triangle of the neck; the glands, whilst enlarging, at first remain discrete, but later form a soft, doughy mass, painless and without signs of inflammation. The individual glands appear to the naked eye to be composed of almost normal lymphadenoid tissue, except that the distinction between the cortical and medullary portions is lost. Microscopically a fair number of endothelioid cells are seen, together with multinucleated cells containing two, four, or more nuclei. The type of tuberculous glands above noted as not tending to suppurate is likely to be confused with lymphadenoma, but the glands are whiter and harder both externally and on section. It may be only by animal inoculation that a distinction can be made with certainty.

Local lymphadenoma must be distinguished from general lymphadenomatosis or Hodgkin's disease and from leucocythæmia with glandular enlargement.

*Treatment.*—A local mass of glands should be excised; if this is impossible, neo-salvarsan given intravenously or X-ray applications.

## Malignant Disease in the Neck.

1. **Primary carcinoma** in the neck, except in the thyroid and outlying portions of that gland, is of rare occurrence. A squamous-celled carcinoma has been traced to an origin in a dermoid cyst; a columnar-celled cancer has with much doubt been ascribed to a branchial cyst originating in hypoblast. A malignant growth in the carotid gland has been called an endothelioma.

2. **Secondary carcinoma of lymphatic glands** may be readily traced to its source in the case of malignant disease of the tongue, parotid, or larynx. The primary growth may be, however, for a long while latent when arising in places where it does not give rise to early symptoms, and then the first sign of the disease noticed is a hard and relatively fixed enlarged lymphatic gland in the neck. The back of the nose, the upper part of the naso-pharynx, the lower part of the pharynx and pyriform fossa, the middle third of the œsophagus, and the cardiac portion of the stomach, are all sites where the primary disease may be for a long while latent. Hence the importance of recognising such malignant glandular enlargements, when an examination may discover the primary growth, and in so doing the mistake of trying to remove such a mass is avoided.

3. **Sarcoma of lymphatic glands.**—A small round-celled sarcoma invades the tissues around the glands and fuses the whole into a mass in which the outlines of the original lymphatic glands are lost. There is rapid extension in the direction of the thorax, and death follows the infiltration of the mediastina and lungs.

*Treatment.*—The treatment recommended is excision whenever practicable.

## Cysts met with in the Neck.

1. **Branchial cysts,** also *branchial sinuses*, *fistulæ*, and *auricular appendages*. —The imperfect closure of a branchial cleft, when this occurs between the epithelial and mucous surfaces, forms a branchial cyst lined by columnar-celled epithelium and containing a glairy mucous fluid; when the epithelial closure is imperfect there is a sinus more or less deep, and, when there persists a communication with the pharynx as well, a branchial fistula. A *branchial fistula* usually opens externally at the anterior border of the sterno-mastoid near its insertion, and internally into the pharynx just behind and below the tonsil. The outer end of the fistula often presents a so-called auricular appendage consisting of a tag of skin containing cartilage; there may also be some malformation of the auricle, and an auricular appendage may be seen without any sinus or a fistula. If merely a sinus, this runs at first superficially, and the outline may be traced by a preliminary injection of methylene blue. In the course of such a fistula there may be found a dilatation into a cyst, and the tract may run deep between the internal carotid artery and internal jugular vein. A fistula is lined by columnar epithelium; it secretes a glairy mucus, and when injected with milk or methylene blue or peroxide of hydrogen the fluid may be seen issuing behind the tonsil.

*Treatment.*—An auricular appendage, sinus, fistula, or cyst should be carefully removed, for it may later on become the seat of malignant disease. The course of a fistula should be first marked by injecting with methylene blue; care will be required where the cyst or fistula is close to the blood-vessels. Having traced a fistula down as deep as possible, a ligature should be applied so as to shut off the pharynx.

2. **Lymphangioma in the neck.**—*Unilocular and multilocular lymphatic cysts, hydroceles, and hygromas in the neck.*—(*a*) The *unilocular cyst or hydrocele* is regarded as a congenital distension of a connective tissue lymphatic space and contains serous fluid. It is situated generally behind the sterno-mastoid, whereas dermoid and thyroid cysts are in front.

(*b*) *Multilocular cysts, or hygromas*, are regarded as congenital dilatations of lymphatic spaces with a new growth of intracystic œdematous fibrous tissue. They form tumours situated in the deep cervical fascia, consisting of a number of cysts of varying sizes lined with endothelium and containing a serous fluid. They appear as soft lobulated, doughy, elastic swellings, either behind the sterno-mastoid in the posterior triangle, or in the submaxillary region. Above the actual tumour there may be some œdematous swelling of the face owing to lymphatic obstruction, or superficially a lymphatic nævus in the skin. They are generally noticed in children soon after birth. When large, such hygromas are prolonged in the deep cervical fascia under the clavicle into the axilla, or into the root of the neck and anterior mediastinum (when they cause dyspnœa), or on to the face. This extension is due to proliferation of the endothelium lining the cysts, along with an increase of fluid and of the intercystic fibrous tissue, causing the tumour to thrust out processes along the fascial planes.

The complications which may occur are sudden swellings from extravasation of blood and also from inflammation. Sometimes an attack of inflammation has been followed by disappearance; on the other hand, infection has occurred which has set up fatal suppuration.

*Treatment.*—The best treatment, if it can be carried out, is excision. Unfortunately the cystic condition is often found to be too widespread; a partial excision may be followed by the disappearance of the rest.

When too extensive for removal, the injection of a drachm of absolute alcohol or a few drops of iodine tincture at a time into one of the large cysts may perhaps set up such an inflammation as to obliterate the cysts and cause the rest of the cystic tissue to shrivel up and disappear. But the iodine must not set up poisoning, and must not be injected into a vein.

3. **Dermoid cysts in the neck.**—Whilst they may be found at birth, they may remain latent until quite late in life. In the *middle line* of the neck a dermoid cyst is generally met with beneath the tongue, in the median raphé between the lower jaw and hyoid bone, having the genio-hyoglossi muscles on either side.

*In the side of the neck* dermoid cysts arise in connexion with one of the branchial clefts.

They are simple in character, having a lining of dermis, with sebaceous glands and sometimes hair, but rarely anything more.

The contents may be cheesy or oily in consistence, and there may be included rounded or flattened epithelial and fatty concretions, also hair. If the cyst has suppurated and there is a discharging sinus the peculiar foul and acrid odour arising from the decomposition of fatty acids may suggest the diagnosis. The cyst wall may undergo malignant degeneration and give rise to a squamous-celled carcinoma.

A sublingual dermoid, when it bulges towards the mouth, pushes the tongue upwards and backwards, stretching the frænum and sublingual folds over it. It is then seen in the middle line behind the incisor teeth as a tense swelling distinct from a ranula, which is lateral; also it has a yellowish white sheen through intact mucous membrane, and this differs from a sublingual lipoma, which is soft and lobulated. It may, however, bulge beneath the chin. Fluctuation is felt by a finger in the mouth and one below the chin.

When of small size and freely movable the cyst can be removed from within the mouth by shelling out, without danger of hæmorrhage or sepsis. A large cyst bulging beneath the chin, and particularly when fixed to the hyoid bone, requires a median incision from the chin downwards, when the cyst should be shelled out from between the genio-hyoglossi without opening the mouth or wounding the lingual artery.

A lateral dermoid may be met with at any point in front of the sterno-mastoid from the auricle to the clavicle. It is important to note whether it is situated deeply, when great care will be required not to injure the carotid, jugular, or vagus nerve. A deep cyst may not be seen until it has suppurated, when the operation will be more difficult still.

*Thyro-glossal cysts.*—See under *Thyroid Gland.*

**Rare cysts in the neck.**—A *blood cyst in the neck*, aneurysm being excluded, is probably a cystic dilatation of a vein, *e.g.*, one of the jugulars. A swelling which is readily compressible, which swells on expiration, has an impulse on coughing, and presents a venous thrill or hum, may readily be diagnosed. If on dissection a cyst full of clot is met with, a communication with a vein may be anticipated.

An *aerocele*, or cyst containing air, is formed by a protrusion of the sacculus laryngis, or of the mucous membrane between the rings of the trachea. Such a cyst is resonant to percussion, is distended by expiration, has a cough impulse, and is reducible by pressure. It is seen in Mussulman criers to prayer, and in trumpeters.

A *pneumatocele* is a protrusion of the apex of a lung into the root of the neck and forms a globular swelling, which is resonant on percussion, crepitates on manipulation, and expands on expiration ; on auscultation vesicular breathing is heard.

**The carotid body.**—*Glandula intercarotica.*—The carotid body is a little oval, reddish brown ductless gland placed behind the bifurcation of the common carotid artery, from which it receives minute twigs. It is developed as an offshoot from the sympathetic, and contains cells which, like the medullary portion of the suprarenal body, are stained brown by chromic acid. It may become the seat of a new growth, very variable in malignancy, which has been called an endothelioma or a perithelioma. The malignant forms rapidly infiltrate neighbouring structures and are essentially inoperable. Attempts have been made to remove some of the more slowly growing, but, however slowly progressing, they are probably best left alone, for the common and internal carotid, the vagus, superior laryngeal, the sympathetic, and hypoglossal nerves, have all been injured.

**Fibrous or neuro-fibromatous enlargement of the superior cervical ganglion of the sympathetic.**—The tumour resembles a large deep cervical gland behind or underneath the carotid vessels. In addition, there are signs of sympathetic irritation or paralysis. Pain, paroxysmal or continuous, is referred to the eyeball or along the blood-vessels of the temple, and is caused by arterial spasm.

*Treatment.*—Removal through an incision behind the sterno-mastoid, retracting forwards the muscle, vagus nerve and large vessels.

## Diseases of the Thyroid Gland, including the Thyro-glossal Tract.

**Pathology.**—(*a*) *In relation to embryology.*—The thyroid gland is mainly developed from the median thyroid rudiment which grows out from the floor of the primitive mouth, and which, as the neck of the embryo elongates, is

carried backwards as a pedunculated process. The cylindrical mass at its lower part becomes bilobed, so that the tract has been compared in shape to an anchor. The left lobe is generally the larger; it forms the pyramidal lobe, and it takes the larger share in forming the isthmus and adjacent portion of the left lateral lobe, whilst the right lobe only forms a small part of the thyroid gland to the right of the isthmus.

Small portions of the lateral lobes of the thyroid gland are also derived from solid outgrowths from the last or fifth branchial pouches, and these unite with the bilobed end of the median thyroid process. In addition, from the third and fourth branchial pouches buds grow out to form the parathyroids. The embryonic thyroid gland shows masses of spheroidal epithelium without alveoli. The alveoli develop as epithelial-lined spaces, into which the cells secrete colloid material, as early as the fifth month. Between the alveoli islands of embryonic thyroid gland tissue may be found persisting.

The *parathyroids* are little brown glands behind and to the inner side of the lateral lobes, along the branches of the inferior thyroid artery. Also detached portions of the thyroid gland, or accessory thyroids, showing the same structure as the fully developed thyroid gland, may be met with. Observations in comparative anatomy and embryology show that the parathyroids are embryonic accessory thyroids, and not distinct glands, all grades between them and the accessory thyroids being found.

(*b*) *In relation to anatomy.*—The thyroid gland, on its posterior concave aspect, clasps the upper part of the trachea and larynx, and its lateral lobes behind come in contact with the œsophagus, especially on the left side. The gland is ensheathed by the pre-tracheal fascia, and when the lateral lobes enlarge, being held together by the strap-like isthmus, they compress the trachea laterally. The lateral lobes overlap the common carotid arteries, whilst the jugular veins lie along their outer border and a little in front. When the lateral lobes enlarge, the common carotids are pushed outwards, but the internal jugular veins, being held in by the middle thyroid veins joining the jugular horizontally, come to lie in front of the outer portions of the enlarged lateral lobes, internal to the line of the carotids.

The superior thyroid artery in its course to reach the apex of the lateral lobe of the thyroid gland may be found where it passes under the upper border of the anterior belly of the omo-hyoid; under the sterno-hyoid and sterno-thyroid muscles it gives off the crico-thyroid artery, and divides into three main branches before entering the gland; the largest passes to the posterior aspect, the other two in front, one to the outer side, one along the isthmus. It is important to recognise this branching of the artery. The inferior thyroid artery is one which should be recognised only to be avoided, as is shown by considering its course. It can only be reached by a deep dissection behind the sterno-mastoid where it runs deep to the internal jugular vein; it then passes behind the sympathetic, vagus, and common carotid artery, beyond which it divides into branches lying in front of and behind the recurrent laryngeal nerve under cover of the lower part of the lateral lobe of the thyroid.

There is a subcapsular venous network on the surface of the thyroid gland joined by branches from its substance. From this a superior set of veins runs upwards over the lateral lobe underneath the hyoid muscles to the internal jugular about the level of the upper border of the thyroid cartilage. A middle set passes transversely, and it is these which tend to draw the internal jugular vein across the front of an enlarged thyroid. The inferior set of thyroid veins from each lateral lobe descends on the front of the trachea to end in the left innominate vein. These are the veins which must be carefully

ligatured when operating for retrosternal goitre, in which they pass forwards in front of the goitre to the innominate vein. Occasionally there is also a median artery, the thyroidea ima. The anterior jugular veins and their communication across the root of the neck will be met with between the skin and the muscles. The recurrent laryngeal nerve, before it passes under the inferior constrictor muscle to enter the larynx, is in close contact with the posterior aspect of the lateral lobe, especially on the left side. Hence, as a result of compression, the left vocal cord becomes weak, but infiltration by cancer causes abductor paralysis not only of the left, but also of the right. The lymphatics run along the course of the veins to the deep cervical and anterior mediastinal glands.

(c) *In relation to thyroid secretion.*—When the thyroid is excited to over-action a condition of hyperplasia is produced in the gland, and also a general effect, hyperthyroidism.

Fig. 291.—Multilocular cystic degeneration of the thyroid gland. Photograph of a microscopic section; the upper part shows proliferation of cells lining the alveoli; the middle, commencing collections of colloid material; and the lower part, large cysts full of colloid material from which the cell elements, except nuclear remains, have disappeared.

The first change is an increased vascularity and an increased formation of colloid. The alveoli show several rows of cells which towards the centre of the alveolus lose their staining properties, become brown, break up, and turn into colloid. The formation of colloid in excess distends the alveolus into a vesicle lined by flattened epithelial cells. There is not at first any marked change in the interalveolar tissue, unless there is an extravasation of blood owing to the excessive vascularity. Hæmorrhages, if slight, may be followed by fibrosis; if large, gland tissue is destroyed.

The condition described above, known as *colloid hyperplasia*, is the change characteristic of parenchymatous goitre and thyroid adenoma. Further change leads to *complete hyperplasia*. The colloid fails to stain, becomes granular, vacuolated, and then disappears. The alveolar walls are infolded, and the epithelial cells, from being cubical, now tend to become columnar and to fill the alveolus. The interalveolar connective tissue is more highly vascular, and inflammatory round cells collect, so that the final result is a solid vascular tissue with an absence of vesicles and of colloid. This is the condition characteristic of exophthalmic goitre. Further changes may take one of two directions:—

1. A return to the normal with a reappearance of colloid within the alveoli.

2. An intervesicular fibrosis with atrophy of gland tissue, the change characteristic of myxœdema. The fresh secretion of the thyroid gland is fluid, and passes from the gland into the veins, not into the lymphatics. It contains iodine in a compound protein molecule, and the colloid within the vesicles

represents a store of iodine in reserve. When the gland is stimulated to over-action, it gets rid of its store of iodine; when iodine is administered or when iodine is contained in the food, colloid tends to re-collect.

*Hyperthyroidism* is the result of excitation of the gland throwing an excess of thyro-toxin into the circulation. It is characterised by a swelling of the gland, cardio-vascular changes, and nervous excitability.

*Hypothyroidism* is the result of gradual gland atrophy; in the young it is seen as cretinism, in adults as myxœdema, or when all the gland has been removed as cachexia strumipriva.

**The causation of thyroid disease.**—Enlargement of the thyroid gland, *i.e.* goitre, is endemic in certain valleys of mountainous districts all the world over. Side by side with goitre and hyperthyroidism there is hypothyroidism from malformation causing cretinism, and in adults degeneration producing myxœdema and tetany. But goitre is not endemic in all the valleys of the same district, and it is also seen in some low-lying districts and even by the seashore. Further observation tends to limit the source of goitre to certain mountain springs; neighbouring springs cause neither goitre nor cretinism, and may be even beneficial to those already affected. Recruits, to escape military service, have drunk from goitrous springs with success. The children born in a goitrous district, whether their parents happen to be suffering or not, become cretins, whereas even goitrous parents, if they move out of the goitrous district, produce healthy children. Cutting off the goitrous water and supplying a valley with healthy water cause goitre and cretinism to disappear, whilst an increase of goitre in Vienna, forming a fresh endemic centre, was traced to the bringing of water from an infected mountain source.

Further researches have tended to show that the water owes its goitre-producing characters to toxins derived from organisms. The water of a goitrous spring, after being well boiled, ceases to cause goitre. The virus has been traced to the soil soaked by such water, to the sediments of tanks, and to the fæces of goitrous patients and animals. Experiments have shown that toxins derived from the intestinal contents of goitrous patients, also the fæces after being passed, can set up goitrous changes in animals (McCarrison). Thus toxins from the mother's intestinal tract may affect the fœtus and cause congenital cretinism or congenital goitre. The toxins of certain acute diseases cause hyperplasia, whilst other toxins fail to do so (Farrant). The effect of such toxins upon the thyroid gland may be through the sympathetic nerve fibres which reach the gland from the superior cervical ganglion along the thyroid arteries and by the superior and recurrent branches of the vagus. Stimulation of the sympathetic fibres excites katabolic action, which empties the colloid reserve, causes compensatory hypertrophy of the gland, and heightens the excitability of the nervous system. Thus a vicious circle is established; the pouring into the blood of an excess of thyroid secretion stimulates the sympathetic, and the stimulation of the sympathetic excites oversecretion by the thyroid gland.

**Thyroid hypoplasia.**—*Hypothyroidism*, *cachexia strumipriva*, or *myxœdema* is shown by œdema of the face and extremities, which become of a pinkish, waxy, anæmic appearance. The hands are spade-like, the skin rough and dry, and the hair scanty; the supraclavicular fossæ are filled by fatty œdematous swellings; the intellect becomes dull. The patients are particularly chilly.

*Tetany* is shown by a tonic spasm of the thumb and fingers, as when cramped by prolonged pressure on the median nerve in the course of an obstetric operation. The feet become rigid, frequently in an equino-varus position. There is

twitching of the facial muscles when the trunk of the facial nerve is tapped (Chvostek), and all these muscles show increased excitability to electrical stimulation. During the acute attacks of tetany bilateral spasm occurs with intense pain, respiration is hindered, and finally the patient becomes comatose and dies.

It is necessary in operating to avoid the risk of these complications, for some patients cannot take thyroid extract or iodine, and thyroid grafting has had only a partial or temporary effect.

**Cretinism.**—*Endemic cretinism* is an infantile, not a congenital, affection. Fœtal bone diseases have been called fœtal cretinism, but they do not occur with any greater frequency where goitre is endemic than in those districts where goitre is only sporadic. In *sporadic cretinism* the thyroid gland is absent or may be even diseased before birth, so that it is doubtless the case that sporadic cretinism is often congenital. The characteristic, therefore, of cretinism, whether endemic or sporadic, is abnormality of the thyroid gland; and bone changes should not, unless the thyroid gland is abnormal, be termed cretinous. Of the changes in the skeleton due to cretinism the less severe type consists in regular dwarfing, with delayed development both of mind and body. A patient may be aged between twenty and thirty, yet look like a boy of less than ten; the epiphyseal lines, as seen by the X-rays, are still cartilaginous, the permanent teeth not all erupted, the sexual organs undeveloped, the mind that of a child. Nevertheless under thyroid treatment such a patient, long past twenty, may grow and his mind develop. In fact, the disease is similar in its effect to that produced by removal of the thyroid gland. The thyroid gland having been removed from a boy of ten, an arrest of growth and development, mental and bodily, took place, so that eighteen years afterwards the man was no taller than at the operation. In the patients more severely affected by endemic cretinism there is a marked arrest of the development of the bones in length, with bending or excessive fragility. The epiphyseal ossification ceases, the cells no longer proliferate and become vacuolated, and fibrous tissue, growing in from the periosteum, invades the

FIG. 292.—Goitre exerting lateral compression of the trachea for which tracheotomy was performed. (St. Bartholomew's Hospital Museum.)

epiphyses. Improvement follows the administration of thyroidin in doses short of causing hyperthyroidism. The grafting in of a piece of a removed adenoma of the thyroid has been followed by relief. The graft has been inserted into the subcutaneous tissue, into the spleen, and into the medullary cavity of the tibia.

**Parenchymatous goitre.**—The gland is generally and uniformly enlarged, retaining its characteristic shape and moving up and down with the larynx in swallowing, although one lobe may be larger than the other; the swelling is soft and elastic. When such a goitre is exposed, the thyroid gland substance is found to be markedly increased in vascularity, owing to dilatation of its blood-vessels. On section it appears like a honeycomb; the alveoli, much distended owing to an increased secretion and fused with one another, contain colloid. On microscopic examination the less distended alveoli are lined with a single layer of cubical or columnar epithelium, which at first becomes swollen, more granular and deeply staining, but in the much-distended alveoli is flattened out. The chief symptoms at first are those of increased rapidity of the pulse and breathlessness on exertion. As the enlargement becomes marked the trachea tends to be compressed from side to side and the cartilaginous rings are softened, so that it comes to be at this spot a fibrous tube, causing dyspnœa and subsequently cardiac dilatation.

A parenchymatous enlargement may accompany the development of adenomata and cysts. Under treatment it may subside, or later shrink into the stage of hypoplasia by the development of interalveolar fibrous tissue, and ultimately into a fibrous or calcified gland with symptoms of myxœdema.

*Treatment.*—Parenchymatous goitre may be relieved by the internal administration of iodine in thyroid extract, especially when there is a tendency to hypothyroidism owing to the colloid secretion being retained in the alveoli. But the treatment requires care, and may have to be stopped owing to the iodine inducing hyperthyroidism, an artificial exophthalmic goitre.

The X-rays may be used with caution.

In young patients about puberty and soon after, subsidence may be anticipated, and surgical treatment should not be hurriedly adopted, and when undertaken be very limited, for fibrosis may ensue in the rest of the gland and myxœdema follow. When the enlargement is progressing, when dyspnœa threatens to bring on cardiac dilatation, then an operation should be undertaken at once.

The general method is to remove the upper portions of the two lateral lobes with the isthmus, leaving the lower and deeper part of each lobe where the inferior thyroid enters, so avoiding injury to the recurrent laryngeal nerves and obviating the removal of the parathyroids. If the enlargement is asymmetrical, then the chief removal is from the lobe most enlarged. At any rate, the amount of thyroid substance left should always be one-sixth, and more whenever there is a tendency to fibrosis.

Where a general anæsthetic can be skilfully administered it should be preferred; local anæsthesia has been often conspicuous by its deficiency. The previous administration of morphine and atropine to reduce mucus and the mixture of oxygen with the ether or chloroform render a general anæsthetic safe and superior to local anæsthesia.

The administration of ether by the rectum is under trial.

The incision is made across the thyroid in the line of the folds of skin, curving slightly downwards and ending over the sterno-mastoids. The skin, platysma, and deep fascia should be raised together from the muscles, dividing the anterior jugular veins and tributaries between clamps. Next a median

incision is made between the sterno-hyoid muscles and then the sterno-hyoid, sterno-thyroid, and sterno-mastoid muscles well retracted. When in extensive cases these muscles have to be divided, the skin flap should be retracted upwards and the muscles divided near the hyoid bone as high as possible. The veins leaving the surface of the tumour are cut between clamp forceps,

Fig. 294.

Fig. 293.

Figs. 293 and 294.—Bronchocele or Goitre. (From photographs kindly lent by Mr. James Berry.)

special care being taken to note the line of the jugular, which, as already mentioned, may be drawn forwards so as to run over the lateral part of the tumour; any large vein, if divided near its entrance into the jugular, should be transfixed by a fine sewing-needle carrying silk and tied on each side. The superior thyroid artery and its branches are clamped before division and the upper part of each lateral lobe gradually separated and drawn forwards. It is important to do this as soon as possible whenever pressure on the trachea is

causing dyspnœa. Whilst thus separating the upper lobes no blunt dissection should be used, nor any attempt made to separate a parenchymatous goitre from within its capsule. Having separated enough, the lower part of each lateral lobe is cut through by dividing the capsule of the gland between clamps, and then the upper half of the lateral lobes removed with the isthmus. It may be more convenient to divide the isthmus early, and then draw the lateral lobes apart to relieve lateral pressure on the trachea. When the removal involves most of one lateral lobe care must be taken in clamping the branches of the inferior thyroid artery not to include the recurrent laryngeal nerve; it is well not to remove too much, but to leave a mass as large as the end joint of the thumb and also the posterior part of the gland capsule. No outlying piece of gland should be removed from near the trachea lest it prove to be a parathyroid.

FIG. 295.—Adenoma of the thyroid gland. (St. Bartholomew's Hospital Museum.) A, Remains of normal thyroid tissue. B, Capsule of adenoma. C, Opaque white growth. D, Semi-translucent softened fibrous trabeculæ. E, Blood-clot.

All hæmorrhage should be arrested by ligature. Deep sutures are necessary when the muscles have been divided; when the division of muscle and the suturing are well away from the line of the skin incision, puckering of the scar is avoided, as the muscles of the neck contract. The skin is united except for a drain in the middle line, which is removed at the first dressing. The drain is required for any hæmorrhage and also for colloid from the divided gland. The main point in after-treatment is to supply fluid by rectal or subcutaneous saline infusions when necessary.

By leaving a small portion of each lower lobe the complications of cachexia strumipriva and tetany are avoided.

**Adenoma and cystic goitre.**—These may be traced to the islands of embryonic thyroid gland tissue between the alveoli, which may be stirred into activity by the same causes as produce endemic and parenchymatous goitre, for experimental hyperplasia of the thyroid induced in animals causes these islands to enlarge. The adenoma as it develops is separated from the

gland substance by a thin capsule. It may at first consist of embryonic or normal thyroid gland tissue, or, by fusion of alveoli, cysts of varying sizes form ; often one cyst becomes much the larger, whilst the others lie in its wall. Sooner or later blood becomes extravasated into the adenoma or cyst, and if this happens rapidly an acute swelling of the gland is caused, sufficient even to produce fatal dyspnœa.

Along with the formation of one or more adenomata or cysts there may be a general parenchymatous hypertrophy. When the latter does not obscure it, an adenoma can be distinguished as a globular, smooth, or partly lobulated swelling within the gland. When cystic the swelling feels more tense.

*Removal of an adenoma or cyst by enucleation or by enucleation combined with resection.*—For a small cyst of the upper part of a lateral lobe an incision in front of the anterior border of the sterno-mastoid is used, but if large, then a curved incision across the front in the line of a collar. The muscles are separated and the capsule of the thyroid gland divided over the cyst after clamping the superficial vessels, and then the cyst or tumour in its capsule is gently enucleated from the gland substance by blunt methods. The thyroid should not be incised over the most prominent part of the tumour, but rather on its lateral aspect, as it is in the latter situation that the correct plane for enucleation can be most readily entered. The greatest care in levering out such a cyst is required when the trachea has been pressed to one side, so as not to tear the deeper part of the cyst, also when the tumour lies behind the sternum—*retro-sternal goitre.* In the latter case the vessels are on the front aspect and are clamped, whilst blunt separation only is used behind in order to lift up the tumour.

Enucleation may be conveniently combined with resection, *i.e.*, with the removal of thinned-out portions of the gland covering the tumour. In that case the portion resected must not be separated by blunt methods, but by dividing the vessels immediately within the capsule of the thyroid between clamps. This is followed by complete arrest of hæmorrhage, deep sutures to diminish the cavity, and drainage for twenty-four hours.

**Thyro-glossal tumours, cysts, and fistulæ.**—(*a*) *At the foramen cæcum.*—A thyroid tumour is seen generally in a girl or young woman. The tumour forms a dark red mass like a cherry or mulberry ; it is not indurated, nor does it continue to grow like a malignant growth. Attention is drawn to it by a temporary congestion or by a chance lesion of the surface which causes some hæmorrhage. An enlargement of the lingual tonsil is made up of swellings of the numerous lymphatic nodules at the base of the tongue, but these lie behind the foramen cæcum, in front of the epiglottis, and are not accompanied by hæmorrhage. The diagnosis may be confirmed by removing a small portion of the tumour for microscopic examination, when thyroid gland tissue will be found. It is then most important to decide whether the patient has any thyroid gland proper. In some cases the rings of the trachea are felt without any isthmus in front of them, no lateral lobes being perceptible also. In such the mass at the foramen cæcum is the important part of the thyroid, and the bleeding should be checked by the application of the cautery and iodides and thyroid extract given internally. If the absence of a sufficient thyroid gland is not taken into account, the result of the removal of such a tumour is the production of cachexia strumipriva.

*A cyst at the foramen cæcum.*—The foramen cæcum is the orifice of an epithelial sinus which extends back beneath the epithelium for about 1 cm., and into which mucous glands open. It represents an epithelial pouch developed at the junction of the primitive mouth and foregut, and exceptionally

it may extend downwards in the neck towards the median thyroid rudiment, but appears to have no physiological connexion with this, for the thyroid gland at all stages of development has closed alveoli. If the foramen cæcum is closed a cyst, single or multilocular, may form beneath. It differs from a thyroid tumour in this situation by being bluish in appearance and feeling tense. The cyst contains mucus, not colloid material, and the wall is lined by stratified or columnar ciliated epithelium. A cyst is removed by gagging open the mouth, drawing forward the tongue, cutting round through the epithelium, shelling out the growth, and uniting by sutures.

(*b*) *In the front of the neck.*—As commonly seen, there is a small tense cyst lying over the thyro-hyoid membrane of a girl or boy. The swelling is in the middle line with the skin freely movable over it, but is fixed behind to the lower border of the hyoid bone. When simply punctured or incompletely removed a sinus persists, which discharges mucus freely as the patient masticates, although there is no communication with the mouth or pharynx.

A vertical incision should be made and the cyst freed from a band connecting it with the isthmus of the thyroid below. Then it separates easily from the thyroid membrane. The cyst was at one time mistaken for a sub-hyoid bursa; but it has no such connexion. The upper pole of the cyst is closely attached to the lower border of the hyoid bone, and a prolongation of the cyst may extend up into the tongue, either behind or in front of the hyoid bone. An injection of methylene blue into a cyst or fistula will enable the tract to be followed up into the median raphé of the tongue towards the foramen cæcum. If it runs behind the hyoid bone, and the upper end cannot be completely excised otherwise, the bone should be cut across, or the middle of the body of the hyoid bone excised. In one case a fistula persisted after the patient had had eight operations, and in a second case the patient had had four unsuccessful ones. In the one case after the middle of the bone had been cut through and the ends retracted, in the other after cutting out a portion 1 cm. in length, the fistula was completely excised and permanent healing obtained. Deep sutures are required when a communication with the mouth in the region of the foramen cæcum has been made.

A *thyroid tumour* may form in the position of the *pyramidal lobe* more or less in continuity with the isthmus. The preliminary point to make out is whether the lateral lobes are palpable; if not, no solid tumour should be removed, for fear of cachexia strumipriva.

**Exophthalmic goitre: Graves's or Basedow's disease.**—This is a disease now regarded as due to a thyro-toxicosis, to thyroid poisoning, and no longer as a primary disease of the nervous system. The disease is distinguished from parenchymatous enlargement and hypothyroidism as follows:—

An exophthalmic goitre on section appears solid, as compared with the honeycomb-like appearance of parenchymatous goitre.

On microscopic examination the solid mass is found to be composed of proliferating cylindrical-celled epithelium, and there is a great diminution or absence of alveoli containing colloid. Whilst all the gland is vascular, there are no marked aneurysmal dilatations of vessels, even where there has been marked pulsation. In early cases solid patches are found interspersed in a parenchymatous goitre. Along with these changes in the thyroid gland there is commonly an enlarged persistent thymus, in some of which Hassall's corpuscles are excessively numerous and large. Also there may co-exist a status lymphaticus, marked by an enlargement of the cervical and other lymph glands, spleen, etc.

The exophthalmos is indicated as follows:—The eyes stare without

frequently winking—Stellwag's sign ; the palpebral fissure is widened, showing an excess of sclerotic round the cornea—Dalrymple's sign ; the upper eyelid does not follow quickly after the eyeball as it turns downwards—Von Graefe's sign, according to Mr. Berry not a reliable one. The only thing found to account for the exophthalmos is an increase of fat in the orbits.

FIG. 296.—Exophthalmic goitre. A, Root of tongue. B, Thyroid cartilage. C, Enlarged thyroid gland. D, Enlarged and lobulated thymus. E, Common carotid artery dislocated from its groove in goitre. F, Internal jugular vein. G, Root of lung. (St. Bartholomew's Hospital Museum.)

The patients are anæmic, and show a diminution of polynuclear white cells from 5,000 per cubic millimetre to as low as 1,200, whilst there is an increase of lymphocytes from 20 to 50 per cent. The earlier cases are further distinguished from the hypothyroidism of myxœdema by not feeling chilly, but the reverse ; they like to wear light clothing and enjoy cold weather. Moreover, they are made worse by iodine and thyroid extract.

In marked cases there is nervous excitability, with muscular weakness, a rapid and irregular pulse of low tension, resulting from cardiac dilatation and degeneration. Exophthalmic goitre may be complicated by albuminuria, glycosuria, bronchitis, and diarrhœa.

Exophthalmic goitre may have a toxic origin, produced by such causes of sepsis as carious teeth, gastric ulcer, appendicitis, uterine infection.

The thyroid gland is commonly enlarged ; it may be extremely enlarged, causing pressure symptoms and dyspnœa by flattening the trachea from the side and even paralysing the left vocal cord.

It may with some enlargement pulsate very markedly. On the other hand it need not be enlarged at all, but then it feels harder than the normal gland.

*The general treatment* of exophthalmic goitre is by rest : iodine in all forms is especially harmful ; indeed, in goitrous nervous people an excess of thyroid extract or other iodine preparation may induce a sort of artificial Graves's disease. When in a state of acute congestion the application of ice to the gland affords relief ; in more chronic conditions marked relief has been obtained by exposure to X-rays.

In all marked cases in which medical treatment has been given a fair trial

without relief operation is indicated, and may be carried out safely before complications, such as marked enlargement of the thymus and lymphatic glands, and cardiac dilatation with toxic degeneration, have set in and threaten life. A period of complete rest in bed should precede operation, unless there is already dyspnœa.

There has been much difference of opinion as to the least dangerous method of inducing anæsthesia. The general opinion is in favour of general anæsthesia and against local anæsthesia for such nervous patients. Local anæsthesia has proved dangerous, owing to poisoning in a weak and susceptible patient by the drug used, cocain, etc.; by recurrent hæmorrhage or necrosis set up by adrenalin; by the artificial œdema, owing to the quantity of fluid used—*e.g.*, 200 cc. of novocain solution have been injected—obscuring structures at the operation, and favouring diffuse suppuration afterwards.

FIG. 297.—Exophthalmic goitre. The proptosis with eversion of the lower lids and marked purulent conjunctivitis are well shown. The right lateral lobe and isthmus were subsequently removed by operation with excellent results.

As for the general anæsthetic, ether by the open method, preceded by an injection of morphin and atropin to diminish the secretion of mucus and supplemented by oxygen, has been largely adopted, but some skilful anæsthetists have preferred chloroform supplemented by oxygen.

The simplest method is to anæsthetise by means of nitrous oxide and oxygen in a room from which the patient can be wheeled into the operating theatre. Then subcutaneous saline infusion is started at once. If necessary, the anæsthesia as above may be supplemented by ether. This method avoids the possible objection to morphin beforehand, and the objection to local anæsthesia mentioned above.

The least dangerous operation is to ligature one superior thyroid artery, either the main trunk at the upper border of the omo-hyoid, or below this just above the gland, including veins and branches of the artery together or

even the apex of the gland itself. This will also cut off sympathetic vasodilator nerve fibres. If this operation is well borne, a fortnight later the isthmus and a portion of the opposite lateral lobe may be removed; if badly borne, then only the second superior thyroid artery is ligatured, to be followed after the patient has improved by removal of part of each lateral lobe. But the surgeon should not be tempted to do too much at any one operation. The main point is to supply fluid by subcutaneous saline infusion during the operation, and on recovering from the anæsthetic by rectal infusion followed as soon as may be by administering fluid by the mouth.

**Thyroiditis** is relatively rare as compared with the other affections of the thyroid gland.

*Acute thyroiditis* may supervene upon a previously enlarged gland, or without previous enlargement the gland may be the seat of acute inflammation. In the course of mumps, influenza, and rheumatism there may be some swelling, which may be expected generally to subside without suppuration. Exceptionally an acute swelling to the size of an orange has occurred in a young girl requiring an incision to relieve tension, even a temporary tracheotomy and the administration of quinine; great swelling, followed by suppuration and gangrene, has complicated puerperal and typhoid fever, erysipelas, and diphtheria. An acute endemic thyroiditis in Brazil has been traced to bug and insect bites introducing a trypanosome (Chagas).

*Chronic thyroiditis*.—An inflammatory enlargement may be due to a syphilitic gumma or to tuberculous infiltration, and may be diagnosed by other indications.

*Ligneous thyroiditis, or Riedel's disease*, is the name given to an "iron-hard" induration of the thyroid gland. From an unknown cause the gland substance becomes replaced by dense fibrous tissue, and the fibrosis, extending beyond the gland capsule, causes early dyspnœa by compressing the trachea. It is distinguished from malignant disease by the skin remaining uninvolved; there is no enlargement of lymphatic glands, and the disease does not cause dysphagia. The patients are between thirty and forty; very marked relief has followed exposure to the X-rays, failing which the isthmus of the gland should be excised so as to leave the lateral lobes free.

**Malignant disease of the thyroid gland.**—Carcinoma is the common form of malignant disease; sarcoma is rare.

*Carcinoma* may appear as a *rapidly increasing enlargement* of the thyroid gland, which gives rise quickly to local complications. A rapidly increasing swelling of part or of the whole of the gland in a patient over forty, especially in a man, points to malignant disease. The growth extends quickly beyond the gland; it infiltrates the recurrent laryngeal nerves, first the left and then the right. The patient is rendered hoarse, when the left vocal cord will be found to have lost mobility; this is followed by abductor paralysis of the right cord and laryngeal dyspnœa. The growth proceeds to infiltrate the trachea, so that the outline of the rings in an X-ray photograph is obscured and then obliterated. The growth may then penetrate the trachea and be seen by the laryngoscope to be encroaching upon the lumen below the vocal cords.

Upon the first signs active steps must be taken to exclude a gumma, and then the tumour should be explored. A sarcoma may be completely excised; for a carcinoma it is necessary to remove the whole thyroid gland, followed by the administration of thyroidin; also the grafting into the neck of a portion of a thyroid adenoma may save the patient from cachexia strumipriva. It has occasionally happened that after a while an outlying accessory thyroid has undergone hypertrophy sufficient for the patient's needs.

In advanced cases a low tracheotomy becomes necessary in order to prolong life.

*Scirrhus carcinoma of the thyroid without marked enlargement* runs an obscure course. It may be recognised by the gland becoming hard and nodular, by small hard lymphatic glands appearing on each side, by infiltration of the recurrent laryngeal nerves, by the obscuring of the outline of the trachea in an X-ray photograph, and by the compression of the trachea. But the first signs noticeable may be those of myxœdema, from which it is distinguishable by the stony hardness of the gland. A still more obscure course may lead to the disease being overlooked until metastatic growths supervene. Secondary growths have appeared on the skull as pulsating tumours, also in the humerus, femur and other bones (see p. 828 and Fig. 348, p. 829). It has been noted that previously existing signs of myxœdema have receded when the metastatic growths have appeared.

## The Thymus Gland.

The thymus originates as an outgrowth from the third, also from the fourth, branchial pouch, forming two connected lobes with processes running up to the trachea representing the primitive diverticula. Hassall's corpuscles, a dermoid cyst, and the peculiar polygonal lobulation represent remnants of the original epithelial gland. But later in fœtal life the gland becomes transformed into lymphadenoid tissue, and the thymus afterwards takes part in general lymphatic gland enlargements. After infancy the thymus shrinks and is transformed into a small mass of fat, which preserves the peculiar lobulation. The gland is enclosed in a capsule, which separates it from the large blood-vessels and from the phrenic nerves. Its blood supply is derived from the internal mammary arteries, and the veins pass out to the left innominate.

**The thymus in infancy** may enlarge and become the cause of dyspnœa—the so-called *thymic asthma*. This enlargement may co-exist with an enlargement of the spleen and lymphatic glands and with adenoid vegetation, constituting the *status lymphaticus*.

The signs of an enlargement of the thymus are stridor, originating below the larynx, and increasing dyspnœa, marked by recession of the chest and muffling of the expiratory cry ; this is followed by attacks of suffocation, during which the larynx does not move up and down. To this is added dysphagia. The child may die suddenly in a suffocative attack. A fulness in the jugular fossa and dulness over the sternum may be noted. In some cases the cause does not lie so much in the actual thymus as in enlarged lymphatic glands by the side of the trachea and bronchi. From these signs should be distinguished those of an attack of laryngismus stridulus, in which there is inspiratory dyspnœa during which the larynx is drawn down, but there is a clear expiratory cry, the attacks are not so severe, and there is a tendency to spontaneous improvement and disappearance.

*Treatment.*—The removal of part of the thymus should be undertaken as soon as the diagnosis is probable ; the suffocative attacks are most dangerous ; tracheotomy does not afford relief and should be avoided if possible ; very little chloroform should be given ; if there is already dyspnœa, perhaps gas and oxygen is safer ; many deaths have occurred under chloroform anæsthesia.

The operation consists of a median incision above the sternum, separation of the muscles, hooking the Thymus upwards and forwards, division of its capsule, and the removal of as much as possible of the gland from within the capsule by blunt methods.

**Enlargement of the thymus complicating exophthalmic goitre.**—When operating for exophthalmic goitre the finger passed behind the manubrium has detected an enlarged and hard thymus. After dividing the sterno-hyoid and sterno-thyroid muscles and retracting the sterno-mastoids, the capsule of the thymus has been seized and opened by blunt dissection. Then with all due care it has been possible to shell out portions of the enlarged thymus from within its capsule. In this way pressure on the trachea and large veins behind the manubrium may be relieved.

**Cysts in the thymus** may arise by myxomatous degeneration of Hassall's capsules. They contain an inspissated material and have sometimes been mistaken for gummata. If they suppurate, the abscess points above the sternum.

A *dermoid cyst* occupying the thymus gland may enlarge and compress the large vessels or the trachea and bronchi. Its position may be indicated by X-ray examination both antero-posteriorly and laterally. A cautious attempt may be made to remove it perhaps after excising the manubrium. A further reason for attempting this is that such a dermoid cyst may undergo malignant degeneration.

An enlargement of the thymus also occurs as the result of sarcoma or lymphadenoma. It may be suspected when dyspnœa and venous congestion are accompanied by fulness at the root of the neck and dulness over the sternum.

# Section XV.

## SURGERY OF THE AIR PASSAGES, PHARYNX AND ŒSOPHAGUS.

### Surgery of the Nose.

### Diseases of the Exterior of the Nose.

**Fractures of the Nasal Bones** are usually the result of direct violence, and they are frequently comminuted. In addition, there may be an injury to the lachrymal bone, nasal duct, nasal septum, frontal sinus, or other neighbouring part. If uncomplicated, little treatment is required, apart from the correction of any deformity that may be present.

**Deformities** of the nose are very common and result from many causes, such as injuries, "broken noses," deflected septum, malformation of the bones of the face, cleft palate, chronic inflammation of syphilis (congenital or acquired) or lupus, abscess of the septum, and intranasal polypi or growths. The deformity may consist in the displacement of the nose to one side or in a thickening or depression of the bridge, and many other disfigurements occur, in all of which the most skilful treatment is required. Recent displacements should be corrected as soon after the accident as possible, and if necessary under an anæsthetic, with the object of preventing any consequent nasal obstruction with all its attendant complications. Other deformities can be repaired by plastic or intranasal operations, or by transplantation of bone or cartilage. Injections of paraffin are now performed but seldom, owing to their liability to occasion fibrosis with indefinite swellings of the skin.

**Acne rosacea** is a dilated or congested condition of the capillaries of the nose, which condition varies in intensity from time to time, increasing after exposure to cold or heat or as a result of the action of hot drinks or alcohol. In its later stages it is usually accompanied by inflammation around the pilo-sebaceous follicles and the consequent formation of red papules and pustules. In long-standing cases the superficial blood-vessels become permanently dilated. The disease is most common in women at the menopause.

*Treatment.*—The cause should be removed where possible, and the diet regulated. Locally, an ointment containing sulphur and resorcin in increasing proportions may be applied. Pustules may be incised, and drops of pure carbolic introduced on a finely-pointed match-stick. In chronic cases dilated blood-vessels may be destroyed by a fine galvano-cautery or by an electrolysis needle.

**Rhinophyma, or lipoma nasi,** is a hypertrophy of the skin, subcutaneous tissue and sebaceous follicles of the nose, not, as the name implies, an increase in the fatty tissue. It is characterised by the formation of irregular, pendulous, lobe-like masses, usually situated on the tip and alæ of the nose, and often of a bluish-red colour. It occurs in elderly men and generally as the result of alcoholism.

*Treatment.*—The masses should be shaved off, leaving the deepest portions of the glands where cicatrisation rapidly takes place, taking care to avoid the cartilages and to make the nose as shapely as possible.

**Lupus vulgaris** may start in the skin over the tip of the nose, or in the vestibule. The disease often begins in the mucous membranes and extends through the tissues to the skin. It first reveals itself as a group of small "apple-jelly" nodules, but the nature of the disease may not be recognised

until these have ulcerated and are covered with crusts. A long-standing crusted eruption in this situation in a young person is generally lupus, and the nodules become more apparent after the crusts have been removed. Untreated, it may lead to extensive destruction of the cartilaginous part of the nose.

*Treatment.*—Ulceration or crusting of the skin should be treated by X-rays in measured doses, the condition being thus reduced to nodules in many cases. Finsen light or salicylic acid plasters may then be employed. Lupus of the mucous membranes is best treated by large doses of sodium iodide (60—100 grains) followed two hours later by electrolysis, when free iodine is liberated at the positive pole and causes an atrophy of the disease (Copenhagen treatment).

**Lupus erythematosus** is sometimes seen upon the end of the nose as a persistent erythematous patch over which the mouths of pilo-sebaceous follicles are dilated and plugged with scales, the patch having a " stippled " appearance. The disease may be limited to the nose, but more often attacks both cheeks and gives rise to the so-called " bat's-wing " lupus. It is distinguished from lupus vulgaris by the absence of " apple-jelly " nodules, and from acne rosacea by its circumscribed form and the absence of daily variations. Continental authorities generally regard the disease as tuberculous, but in this country it is thought by many to be due to a toxin unrelated to tubercle. In the natural course of the disease the patches disappear after many years, leaving fine atrophic scars.

*Treatment.*—In the early stages lotio calaminæ co. may be applied, and the parts should be protected from extremes of heat and cold. Large doses of quinine or salicylates may be given internally. In later stages mild caustic applications should be employed, the most useful being carbon-dioxide snow.

**Syphilis.**—The most common form of syphilis of the nose is a tertiary manifestation known as acneiform syphilide. It is characterised by the appearance of coppery-coloured nodules of the size of a pea, or larger, which are grouped but not coalescent, and which eventually ulcerate, become encrusted, and leave punched-out scars. This affection may simulate lupus vulgaris or acne rosacea. It is distinguished from acne rosacea by the occurrence of ulceration, and from lupus vulgaris by its more rapid development, by its onset in adult life, and by the grouping without coalescence of the nodules, ulcers or scars. Gummatous syphilides also occur in the mucous membranes and skin of the anterior part of the nose, and lead to ulceration with rapid destruction of the end of the nose, including both cartilage and bone, but at the present day such cases are less often seen than formerly.

*Treatment.*—Rapid healing can often be obtained by one or more intravenous injections of neo-salvarsan. These should be followed by mercury and iodides internally, or by inunctions or intramuscular injections of mercury.

**Rodent ulcer** frequently occurs in the sulcus between the ala of the nose and the cheek or the inner side of the eye. It begins as a pearly nodule, which eventually ulcerates and becomes crusted at its centre. The ulcer which results has a characteristic narrow raised " rolled-edge." If neglected, the disease usually leads to destruction of one ala, with exposure of the front of the septum ; or, in long-standing cases, to still wider destruction of the nose, lips, and cheek (see p. 659).

*Treatment.*—X-rays, radium applications, diathermy or repeated freezings with $CO_2$ snow form the best treatment for these cases, in which excision cannot be effected without producing considerable deformity.

**Epithelioma,** commencing at the anterior nares, and other malignant

growths, such as sarcoma and endothelioma in the nasal fossæ, also may cause ulceration of the skin. Such growths must be freely excised regardless of the deformity which results.

### Examination of the Nasal Cavities and Post-nasal Space.

For the diagnosis of internal diseases the nasal cavities must be illuminated by a powerful artificial light in a darkened room, the alæ being separated by a

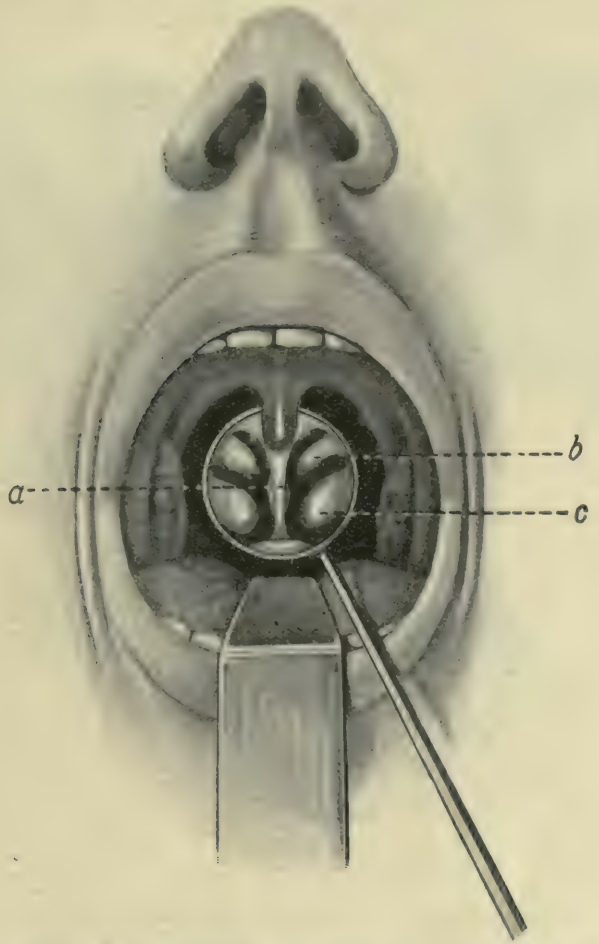


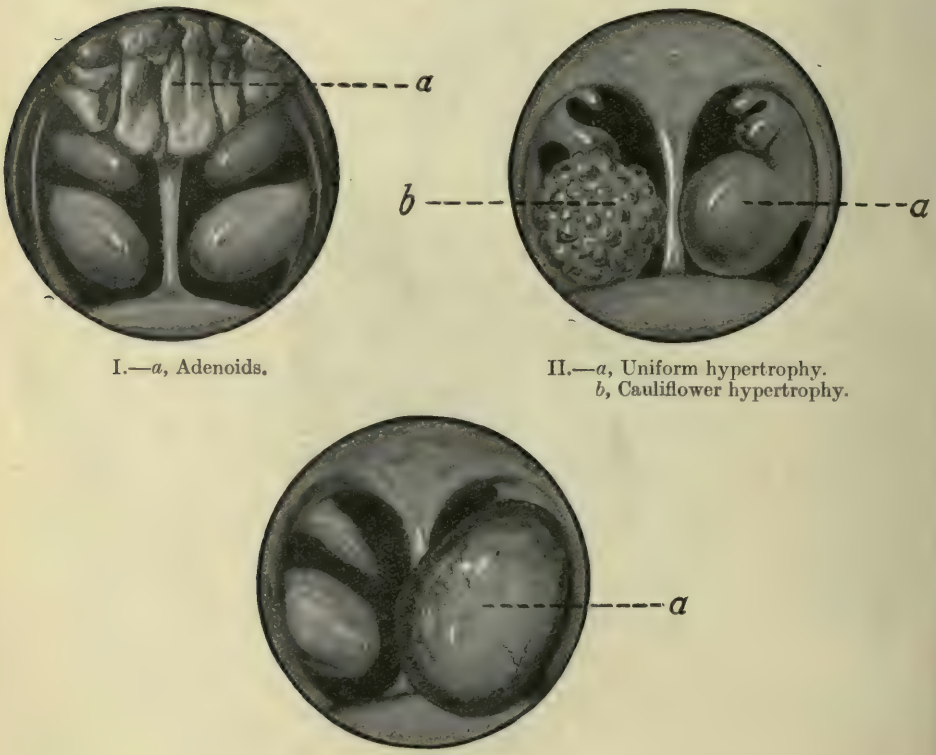

FIG. 298.—Posterior rhinoscopy. *a*, Septum. *b*, Middle turbinate. *c*, Inferior turbinate.

nasal speculum. The examination, which necessitates an intimate knowledge of the anatomy of this region, should include the vestibule or entrance to the nose; the septum, seen by turning the head to one side; the inferior turbinate and floor of the nose, visible when the chin is depressed; and the middle turbinate and upper portion of the nose, seen with the head thrown back. The condition of the mucous membrane also must be noted, together with the contents of the nasal cavities, such as mucus, muco-pus, polypi,

spurs and the like. Whenever necessary a solution of cocain (10 per cent.) containing three or four drops of adrenalin (1—1,000) may be sprayed into the nose, or applied with wool, to constrict the membranes. The post nasal space and posterior nares can be examined indirectly by means of a small simple mirror placed at the back of the throat (Fig. 298), or they can be explored by the finger passed behind the palate. Various rhinoscopes have been invented, but have no great practical utility.

### Diseases of the Nasal Fossæ.

**Epistaxis** is a symptom of many and varied conditions. In childhood




I.—*a*, Adenoids.

II.—*a*, Uniform hypertrophy.
*b*, Cauliflower hypertrophy.

III.—*a*, Polypus.

Fig. 299.—Posterior rhinoscopy.

it is very common, and may result either from rhinitis, foreign bodies, adenoids, and other affections in the nose, or may occur spontaneously from congestion of the mucous membranes. In girls it is especially common about the age of puberty. Amongst malingerers it is a well-known affection. There are, however, many *local causes*. These include injuries and operations with which both primary and secondary hæmorrhage occur; bleeding from the vessels at the anterior part of the septum (" seat of election "). The hæmorrhage is often unilateral and copious; it is caused by chronic superficial ulceration and crusting (*rhinitis sicca*), a condition which persists for long periods and gradually involves the walls of the vessels—every time that a crust is disturbed hæmorrhage is likely to occur (see *Perforating ulcer*, p. 721); rhinitis,

sinusitis, and ulcerations caused by syphilis, tubercle, foreign bodies and the like; tumours such as bleeding polypus of septum and naso-pharyngeal polypus.

*Constitutional causes.*—Epistaxis is common with certain organic diseases of the heart, lungs, kidney, liver, and brain; with different forms of anæmia, chlorosis, leukæmia, pernicious anæmia, hæmophilia, purpura and scurvy; in the early stages of fevers such as typhoid, whooping-cough, measles, scarlet-fever and influenza; in high altitudes and tropical conditions; and lastly with certain poisons, more especially in chronic alcoholism.

The symptoms are usually evident, and are often preceded by a sensation of fulness in the head, pulsation of vessels, dizziness or tinnitus. The blood may come from one or both nostrils: it may pass into the pharynx and be swallowed, and if vomited will simulate hæmatemesis, or it may trickle into the larynx, causing cough, and be mistaken for hæmoptysis. When the bleeding is profuse, or very frequent, profound anæmia may result, but is rarely fatal.

*Treatment.*—When considering treatment it is important to discover the cause. Bleeding from septal vessels is easy to recognise, and can be controlled by the application of cocain (10 per cent.) and adrenalin. To prevent a recurrence the bleeding vessel should be completely divided with a galvano-cautery, and afterwards an ointment applied to promote the healing. Other local causes, such as tumours, can be treated surgically, while with constitutional diseases medical treatment alone may be necessary. When there is no obvious local cause the patient should be made to keep quiet, either lying on the back or propped up in bed; cold applications should be made to the nose, face and neck; or wool soaked in peroxide of hydrogen (10 volumes) or a weak solution of cocain and adrenalin may be sprayed into the anterior nares. If such remedies do not arrest the bleeding the nose must be plugged after a thorough application of cocain. In most instances it is sufficient to insert strips of white gauze through the anterior nares until the whole of the nose is filled with a firm pack, which may be left *in situ* for twenty-four or forty-eight hours. Rarely it may be necessary first to plug the posterior nares. For this purpose a roll of gauze ($1\frac{1}{2}$ by $\frac{3}{4}$ inch) is firmly tied to a double strand of silk; a small rubber catheter is passed through the nose; to the part which appears in the pharynx one end of the silks is attached; the catheter is then withdrawn with the silks, and these are pulled until the roll of gauze is firmly fixed in the posterior nares. They should then be tied over a second roll of gauze placed outside the nostril. The other ends of the silks remain hanging out of the mouth, and can be used later for removal of the plug.

## Diseases of the Septum.

**Deformities.**—Deflections of the septum are common, and occur in some degree in almost every individual. They may be the result of injury or congenital malformation, but are more often produced by irregular development, such as faulty dentition, narrow, high-arched palate, or misshapen nose, and are especially common with the nasal obstruction or mouth-breathing of rhinitis or adenoids in childhood. In most cases the deformity begins during the early years, but it is not necessarily troublesome till later in life. The common forms are: (1) Displacement of the triangular cartilage, forming a prominence into one or other vestibule and commonly associated with an irregular thickening of the columella (Fig. 300). (2) Spurs, which may be

cartilaginous or bony and often extend some distance posteriorly, forming crests which project into the middle meatus of the nose (Fig. 300). (3) Deflections of various shapes, such as simple projections, S-shaped curves, thickenings or displacement of cartilage or bone.

Such deformities, even in marked degrees, may give rise to no inconvenience, and in such cases it is wrong to draw the patient's attention to them. On the other hand, they may cause troublesome nasal obstruction with rhinitis and consequent catarrh. In such cases the inferior turbinate on the concave side is often hypertrophied.

*Treatment.*—In deciding what treatment is necessary it is important to pay more attention to the symptoms described by the patient than to the appearance of the deformity in the nose. Operation is indicated for the correction of external disfigurement; to restore normal respiration; to cure catarrh, colds or sore throats, especially when associated with Eustachian deafness; to promote better development of the chest; for headaches due to nasal obstruction; and, occasionally, to facilitate intranasal operations.

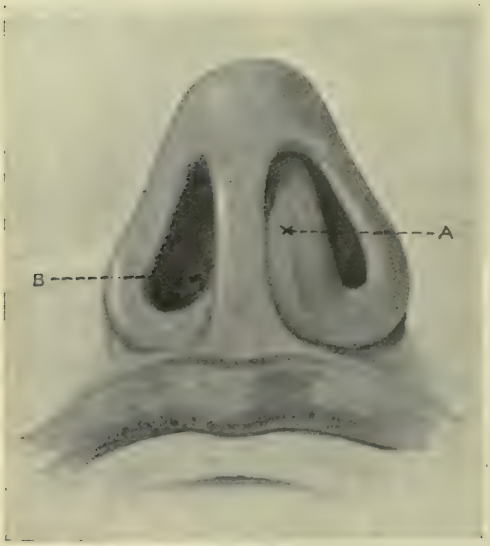



FIG. 300.—Deflected septum. A, Displaced triangular cartilage. B, Spur.

**Submucous resection of the septum** can be carried out under local or general anæsthesia. To prevent troublesome bleeding the nasal cavities should be plugged with wool soaked in equal quantities of cocain (10 per cent.) and adrenalin (1 in 1,000) a quarter of an hour before the operation is begun. Care should be taken that the cocain is not swallowed. When possible a vertical incision is made through the mucous membrane immediately in front of the prominent part of the deflection on the convex side of the septum. The incision commences at the roof and passes downwards to the floor of the nose. The muco-periosteum is separated with a small elevator from the convexity of the septum, care being taken not to buttonhole the flap. A cut is then made through the cartilage in the same position as the original incision, and the elevator is introduced through this opening to separate a flap of muco-periosteum from the concavity of the septum. The speculum is reintroduced in such a manner that the two flaps lie to the outer side of the blades, where they are protected, and the bared cartilage and bone are held between the two blades. The cartilage is then removed with the knife, and the bone with cutting forceps or chisel and mallet. When the whole deformity has been taken away the two flaps are allowed to fall together with their raw surfaces in apposition, and the original incision is united with one or two horse-hair sutures. Afterwards it may be necessary to remove a portion of the inferior turbinate, especially the anterior end of the bone in the concave side. In

order to keep the flaps in apposition, gauze is packed into both nostrils. The operation, if well carried out, gives better results than older methods. No perforation should be made, and the septum should be perfectly straight, thus allowing free breathing through both nostrils. The gauze is removed twenty-four or forty-eight hours after the operation, and further plugging is unnecessary unless there is copious hæmorrhage. In rare instances it may be necessary to insert some form of rubber plug for a short time, to divide adhesions with the cautery, or to remove further portions of the inferior or middle turbinates when these are much hypertrophied.

**Hæmatoma.**—The bleeding is due to trauma, and extravasation occurs under the muco-perichondrium immediately after the injury. Hæmatoma is frequently associated with fracture of the cartilage, and if seen a few days later may be indistinguishable from abscess. On this account, and because of the danger of necrosis of the cartilage from deficient blood supply, the blood should always be evacuated by free incisions through the mucous membrane on both sides of the septum.

**Abscess** is usually due to infection of a hæmatoma after injury. In rare instances it may result from rhinitis, or from any acute infection such as measles and scarlet fever. Children are more often affected than adults. The swelling is always symmetrical, and causes complete obstruction of the nasal fossæ. Free and early incisions should be made on both sides, and the openings should be probed for a few days to prevent retention of discharge.

**Gummata** affect the periosteum of the bony septum both in acquired and congenital syphilis. They are more common in adults than in children. They may be unilateral. If neglected, rapid ulceration ensues, leading to necrosis with perforation of the septum, extensive destruction of the bones or the formation of sequestra, and later falling-in of the bridge of the nose. Such ulcers are deeply excavated, covered with foul discharge, and surrounded by a red and greatly-swollen mucosa which bleeds readily when touched. The disease often yields quickly to treatment as described on p. 716.

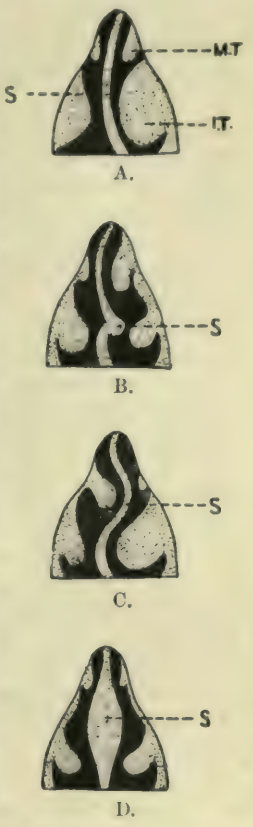



FIG. 301.—Deflected septum. A. Simple B. S-shaped. C. Spur. D. Thickening. S. Septum. M.T. Middle turbinate. I.T. Inferior turbinate.

**Perforations.**—The so-called perforating ulcer of the septum occurs near the anterior end of the cartilaginous septum, and never extends to the bone. It runs a very chronic course; crusts form and are detached (see *Epistaxis*), and the process continues until the cartilage is destroyed, leaving a small oval or circular aperture with thin, sharp edges. Without treatment such perforations tend to increase in size. The cause of this condition is uncertain. Other perforations may be due to trauma, operations on the septum, syphilis, tubercle, lupus, acute infections of all kinds, and, rarely, to other chronic diseases, such as atrophic rhinitis.

**Tumours.**—Tumours of the septum are very rare. The only common varieties are fibro-angioma, carcinoma and sarcoma. Fibro-angioma,

the so-called *bleeding polypus of the septum*, grows from the perichondrium of the triangular cartilage, and is usually a soft, vascular, rounded and sessile tumour appearing like a small cherry and with an inveterate tendency to bleeding. This tumour is not malignant, but recurs locally unless freely removed with the perichondrium. It can be easily distinguished from carcinoma and sarcoma by sections of the tumour after removal.

## Rhinitis.

**Rhinitis,** or nasal catarrh, occurs in acute and chronic forms and is often recurrent. In many instances a definite infection with specific organisms can be discovered. Thus *simple acute rhinitis*, or "cold in the head," is often associated with special organisms—more commonly pneumococci, the *bacillus catarrhalis*, the influenza bacillus, or the *bacillus coryzæ segmentosus*, either alone or in combination. The same organisms and others, such as streptococci, are often found in *acute rhinitis* of constitutional diseases such as measles and other fevers. The Klebs-Lœffler bacillus causes a chronic inflammation known as *membranous rhinitis*, a form of diphtheria met with in weakly children. The discharge is muco-purulent: it is always associated with a white exudate adherent to the mucous membranes, and often with epistaxis. When unilateral it is easy to confuse this condition with rhinitis caused by a foreign body.

**Foreign bodies** are frequently found in the nose. Peas, beads, buttons and every conceivable article which is small enough to pass through the anterior nares may be inserted by young children. They cause a unilateral irritation, with muco-purulent or fœtid discharge and a tendency to slight epistaxis. In some instances they may remain for long periods and become encrusted with mineral salts (**rhinoliths**). If the foreign body is soft or covered with granulations the diagnosis may be exceedingly difficult; and any child who has a unilateral purulent discharge should be carefully examined, if necessary under a general anæsthetic. Hard bodies are easy to detect with a probe, and generally can be removed with a blunt hook, forceps, or curette. In some instances it is advisable to push the foreign body into the naso-pharynx and remove it through the mouth, taking care that it does not fall into the larynx. Rhinoliths also occur in adults from deposit of phosphate or carbonate of lime upon a nucleus of inspissated mucus or crust. Animate foreign bodies such as flies, maggots, and other parasites are met with, though rarely in northern latitudes. *Purulent rhinitis* also may be due to specific organisms. Many other forms of rhinitis occur, such as rhinitis due to tubercle, lupus, rhino-scleroma, glanders, gonorrhœa and syphilis. The last is seen in congenital and acquired disease. With congenital syphilis the inflammation may start in the first few weeks of life, and the obstruction and catarrh cause the noisy respiration popularly known as "snuffles." Later, ulcerations and periostitis may supervene, with destruction of the nasal bones and cartilage, sinking-in of the bridge of the nose, and perforation in the septum or palate. In the worst forms the ulceration is extensive and is liable to destroy the outer parts of the nose, thus causing great deformity. Similar symptoms with rapid ulceration and loss of tissue may arise in acquired disease.

There are also in the nose many inflammatory conditions, such as *hypertrophic rhinitis*, which result from unknown causes. In this condition the mucous membrane of the inferior turbinate becomes congested and greatly thickened by increase of the fibrous tissue in the submucous layers.

This may result in the enlargement of the anterior or posterior ends alone, or in a general thickening along the bone, which is then covered by an irregular cauliflower-like mucosa. The discharge from the nose is excessive, and nasal respiration is obstructed. Treatment of the general health, the local application of sprays or lotions, and burning with a galvano-cautery will usually arrest the disease. To cure excessive hypertrophy it is often necessary to remove with scissors the mucosa covering the anterior or posterior ends of the inferior turbinate, or, rarely, to trim the whole length of the bone. When large portions are removed the lower part of the nose should be plugged firmly with gauze, otherwise hæmorrhage may be severe and difficult to control. The packing should not be removed in less than twenty-four or forty-eight hours. Free removal of the inferior turbinate should not be undertaken lightly for fear of causing dry or crusting rhinitis.

**Atrophic rhinitis (ozœna).**—The characteristic signs of this disease are a copious discharge of foul muco-pus, with tendency to crusting in the nose; a shrinking of the mucous membrane in the lower parts of the nose, especially that which covers the inferior turbinate bones; and abnormal width of the nasal fossæ. In most cases there is also atrophy of the olfactory nerves, so that the sense of smell is lost. The disease may involve the accessory sinuses, the sphenoidal cavities being principally affected. On examination the nasal fossa appears unduly wide, and the naso-pharynx can be easily seen through it. The upper part of the pharynx is usually dry or coated with crusts. In rare instances the larynx and lower air-passages are also diseased, and dyspnœa may result. The discharge constantly passes into the stomach, and may cause indigestion, colitis, and other alimentary disorders. In such cases the patients are often in poor health owing to septic absorption: they suffer from severe headaches, and their life is made miserable by the ozœna which they are unable to conceal from their neighbours.

Atrophic rhinitis commonly begins in childhood as a purulent rhinitis and persists for many years, but commonly disappears after the age of forty. Women are more susceptible than men. Recent researches have shown that this complaint is probably due to an infection by the bacillus of Perez. In old-standing cases secondary infections are common and Friedlander-like bacilli are generally present in large numbers. In a small percentage of cases there is a definite history of syphilis, and it is possible that the latter is one of the predisposing causes. There is no evidence that the disease is connected with tuberculosis. Although no cure has yet been discovered, the most distressing symptoms can generally be relieved. Every effort should be made to improve the general health. The nose must be cleansed frequently with a lotion containing bicarbonate of soda and salt, or peroxide of hydrogen (5 volumes) when the crusts are offensive or adherent. The nose should then be blown sharply, and an oily spray or ointment inserted. To prevent further crusting a paste containing dichloramine T ʒj., bismuth nitrate ʒss., and white liquid paraffin ʒss. is very effective. In very severe cases, plugging the nose with gauze soaked in an antiseptic oil for twelve hours is also useful, and may be repeated for several days until the discharge is less offensive.

**Vaso-motor rhinitis.**—There are two common varieties, namely, *hay-fever* and *paroxysmal rhinorrhœa*. In the former the rhinitis is induced by inhalation of dusts, especially the pollen of certain grasses and flowers, and occurs in the summer alone. The symptoms are well known, and comprise sneezing, profuse discharge of watery mucus, hypersensitiveness and spongy swelling

of the mucosa covering the septum and inferior turbinates, lachrymation and redness of the conjunctiva, frequently followed by troublesome headaches. Hay-fever is common among the upper middle classes, especially in people of neurotic disposition, but rarely occurs in "rustics" or in young children. After reaching their greatest virulence about puberty, the yearly attacks tend to become less severe towards middle life.

Paroxysmal rhinorrhœa is the other common nasal neurosis of town dwellers, and nothing is known about its causation. The attacks may appear at any period of the year, especially in the damp months. On rising from bed in the morning the patient complains of an intense irritation in his nose which makes him sneeze; and this is followed by a rhinorrhœa which lasts for two or three hours, leaving a sensation of general slackness and inability to work. A second attack may occur later in the day or during the night, the patient being wakened from sleep.

To cure a case of vaso-motor rhinitis is exceedingly difficult, but there are many ways of relieving the symptoms. Whenever possible the patient should travel to the sea or take a sea voyage; he should receive treatment for his general health, and use local applications in the nose, such as pollantin, anæsthesine, atropin or adrenalin. Severe cases may be benefited by burning with the galvano-cautery, protective inoculations, or rest in bed.

Both forms of vaso-motor rhinitis are closely related to asthma. They must not be confused with the rare condition of **cerebro-spinal rhinorrhœa,** in which there is a discharge of cerebro-spinal fluid from the nose. Such cases may be due to operations for removal of tumours of the nose, when a portion of the base of the skull, such as the cribriform plate, has been removed; to injuries such as fractures of the base of the skull, which may cause a discharge of cerebro-spinal fluid from the nose or from the ear, often persistent for months; or to chronic hydrocephalus. In some instances they are spontaneous and of uncertain origin. Several remarkable cases have been reported in which a large quantity of fluid has been discharged every day; in some instances the flow is intermittent, and may persist for long periods. Meningeal infection is uncommon. There is no known method of curing the condition.

## Nasal Polypi.

**Mucous polypi** usually grow from the muco-periosteum covering the ethmoid, especially from the middle turbinate bone and from the mucosa lining the ethmoidal cells. They may also be found in the frontal and antral cells. They are caused by a chronic inflammation of these membranes, and are not true tumours of the bones. The normal tissues of the mucous membrane may all be increased, or one element may predominate. Thus soft or myxomatous polypi are common, whereas fibrous and vascular swellings are rare. Their cause is at present unknown. The older view, that they are secondary to periostitis and necrosis of the bone (*necrosing ethmoiditis*), is incorrect. It is much more probable that they are due to infection of the lining membranes, especially those of the ethmoidal cells. The usual symptoms are a sensation of stuffiness in the nose, nasal voice and discharge, the last varying according to the degree of sinusitis that is present; in simple cases the mucus is colourless. People with nasal polypi are extremely liable to "colds," and often complain of deafness, both of which can be relieved by removal of the cause. In many cases they suffer from partial or complete loss of smell (*anosmia*). Certain reflex symptoms such as asthma and cough

are commonly associated with this disease. Mucous polypi are generally multiple, and both sides of the nose are often affected. They are far more common in adults than in children. They may be sessile or pedunculated. On inspection through a speculum they appear as semitranslucent, movable bodies, and are soft to the touch of a probe. When far forwards in the vestibule of the nose they may become inflamed, and are pinker in colour or even black after hæmorrhage or strangulation. They may then be mistaken for sarcoma. With posterior rhinoscopy it is often possible to detect a polypus which was not apparent through the front of the nose. When large enough to fill the nose they block the flow of mucus from the sinuses, and suppuration may then supervene. Later there may be necrosis of the ethmoid, and an offensive antral discharge which the patient himself perceives; or the frontal cells may be blocked and troublesome headaches result. It

Fig. 302.—Nasal polypi.

must never be forgotten that true mucous polypi are commonly associated with malignant disease of the nose. In such cases there is a tendency to epistaxis, and the discharge is more copious and purulent. The following conditions must also be distinguished from polypi: (1) Deflected septum: the obstruction is due to a prominence of the septum, and a corresponding concavity can be seen on the opposite side. (2) An enlarged turbinate bone: this is of pink colour and firmly attached to the outer wall of the nose; it shrinks and becomes paler when painted with cocain. (3) A post-nasal tumour (*e.g.*, naso-pharyngeal polypus) is harder, and firmly attached to the roof of the pharynx: the fact can be determined by passing the finger behind the palate. (4) An encephalocele, protruding through the base of the skull, with or without a cleft in the palate, would be seen in a child and would exhibit a cough impulse and pulsation: it could never be mistaken for a polypus.

**Antro-choanal polypus.**—This polypus is always single, and has a long, slender peduncle attached to the outer wall of the nose in the neighbourhood

of the opening of the antrum. Such a polypus may grow to a large size, and usually lies partly in the posterior part of the nasal fossa and partly in the naso-pharynx. It gives rise to a free discharge of mucus, and to a nasal obstruction which may be bilateral when the pharyngeal portion is large enough to overlap both choanæ. Diagnosis can always be made by posterior rhinoscopy.

**Fibrous and malignant polypi** (see *Tumours of the Nasal Fossæ*, p. 730).

*Treatment of mucous polypi.—Removal by snares or forceps.*—This is the method which is most often adopted, the operation being performed under cocain anæsthesia. A cold wire should be used in preference to the galvano-cautery snare, since the latter causes troublesome inflammation of the bones.

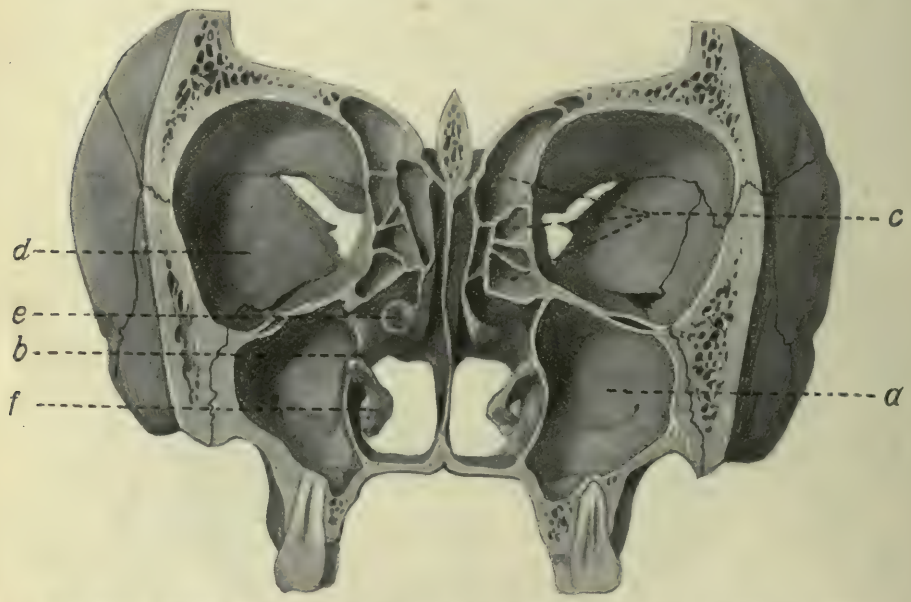



FIG. 303.—Section showing relation of accessory sinuses to nasal fossæ and orbits. *a*, Antrum. *b*, Opening of antrum. *c*, Ethmoidal cells. *d*, Orbit. *e*, Middle turbinate. *f*, Inferior turbinate.

The loop should be passed around the polypus as high up as possible and then tightened, so that the base of the polypus can be pulled away with a fragment of the bone to which it was attached. In many cases it is necessary to remove a portion of the middle turbinate bone. If preferred, forceps may be used for taking away the polypi.

*Curetting.*—When polypi recur quickly, or are associated with ethmoidal suppuration, they should be removed more freely with a curette. In this operation the greater part of the middle turbinate is taken away, and the nasal surface of the ethmoidal cells is also extracted. Great care should be observed not to turn the curette upwards towards the cribriform plate, nor to press so firmly outwards as to rupture the orbital plate, otherwise meningitis or orbital hæmatoma or abscess may supervene. It is unnecessary to plug the nose after these operations, but it should be cleansed by daily irrigation. Removal of a large antro-choanal polypus is sometimes difficult, and may require a general anæsthetic.

## Diseases of the Accessory Sinuses.

**Sinusitis.—Infection of the maxillary antrum.**—This sinus, which is the largest accessory nasal cavity, is an air-space in the upper jaw, lined by a thin columnar-celled mucosa and communicating with the posterior part of the middle meatus by a small opening situated near the roof of the antrum. Into the floor project the roots of the molar teeth. The lining membrane may become infected by an extension of inflammation from the nose or from septic teeth. Infection from the mouth is chiefly seen among the poor and those who have septic stumps or pyorrhœa alveolaris. Nasal infections are commoner than dental in the better classes of society. The influenza bacillus, streptococci, Friedlander's bacillus, pneumococci, staphylococci and diph-

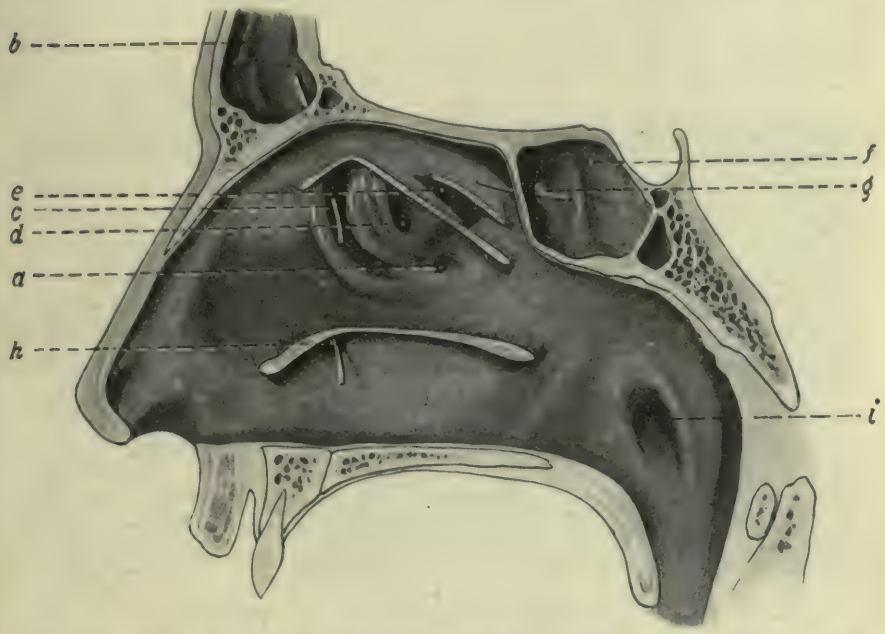



FIG. 304.—Outer wall of nasal fossa showing position of openings of accessory sinuses. *a*, Antral opening. *b*, Frontal sinus. *c*, Frontal opening. *d*, Anterior ethmoidal opening. *e*, Posterior ethmoidal opening. *f*, Sphenoidal sinus. *g*, Sphenoidal opening. *h*, Opening of nasal duct. *i*, Eustachian tube.

theroid organisms, either alone or in combination, are common causes of inflammation in the order in which they are named. Both acute and chronic inflammations occur, and produce a copious discharge of yellow muco-pus or pus which is often offensive (*empyema*). This escapes through the middle meatus and flows to the front of the nose or back of the throat. In acute empyema the pus may be retained, and then causes severe pain over the cheek, and fever. Chronic forms can be distinguished by the source of the discharge under the middle turbinate, and by the dark shadow observed with transillumination through the mouth (Fig. 205). A definite diagnosis can always be made by puncture of the antrum with a fine trocar and cannula through the inferior meatus of the nose. It should be remembered that sinusitis of the antrum is often complicated by discharge from other cavities, such as the fronto-ethmoidal and sphenoidal cells.

*Treatment.*—Inhalations of steam containing menthol or washing out the antrum through a fine cannula are the best treatments for acute empyema, but it may be necessary to repeat the treatment for several days to effect a cure.

**Intranasal drainage.**—Under cocain or gas anæsthesia an opening is made with a perforator below the anterior third of the inferior turbinate ; it should be large enough to allow of frequent irrigation with a small curved cannula. In cases which are not cured at the end of a fortnight the opening should be enlarged so that the cavity can be curetted.

**Drainage through a tooth socket.**—Septic teeth when present should be removed, but even if the sinusitis is dental in origin it is rarely advisable to drain the cavity into the mouth. The practice of perforating through the alveolus and inserting plugs of various descriptions to keep the opening patent is of little value except for drainage.

**Caldwell-Luc operation.**—A free opening is made under the upper lip through the outer wall of the antrum and a second opening into the inferior meatus of the nose. This operation affords a free exposure of the cavity and enables the surgeon to determine whether the lining membrane must be completely removed or not. Afterwards the external incision is allowed to close, and free drainage is maintained into the nose. Such an operation is more radical than those previously described, and should be reserved for intractable cases. It should be undertaken also when there is any suspicion of malignant disease.

FIG. 305.—Transillumination of antra. Right, normal. Left, dull. A, Pupil. B, Infraorbital crescent.

**Infection of fronto-ethmoidal cells.**—These cells are a complicated gallery of air-spaces communicating with the middle meatus, their chief opening being the infundibulum or tube from the frontal sinus under the anterior extremity of the middle turbinate bone. Inflammation in this region results from any nasal infection, and is commonly associated with disease in the antrum. In acute infections the mucus or muco-pus may be retained and give rise to intense supraorbital headache with tenderness and febrile disturbances. Chronic inflammation may result in mucocele (retention of mucus and external swelling) or suppuration with discharge of pus into the middle meatus. In most instances the middle turbinate and middle meatus are also inflamed and swollen, and mucous polypi are frequently present. The symptoms are severe, intermittent pains over the orbit or on the top of the head and localised tenderness with occasional swelling of the skin. By a combination of transillumination and X-ray photography it is often possible to determine the size of the frontal cells and whether they are healthy or not, but a

definite diagnosis of suppuration can be made only by passage of a cannula into the sinus.

*Treatment.*—Acute inflammation of the fronto-ethmoidal region can generally be relieved by intranasal treatment, and the majority of chronic infections can be similarly treated. In the latter cases it may be necessary only to remove the anterior end of the middle turbinate, to extract the polypi, and to continue to use lotions for cleansing the parts. Some patients can be greatly benefited by curetting the ethmoidal cells. The indications for an external operation include chronic purulent sinusitis with fever; persistent headache or pain; persistent discharge from the fronto-ethmoidal cells which cannot be relieved by intranasal treatment; recurring polypi produced by a fronto-ethmoidal discharge; necrosis or fistula of the frontal sinus; sinusitis associated with intracranial complications; and tumours of the frontal sinus.

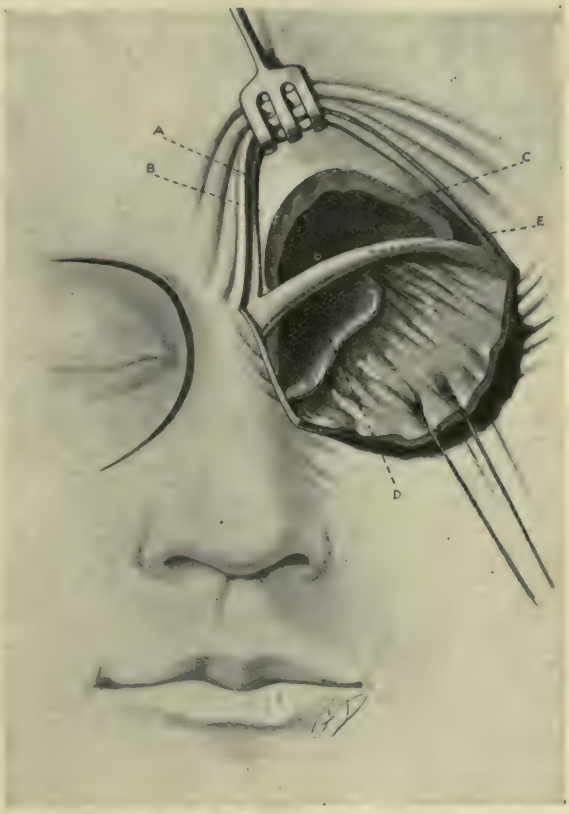



FIG. 306.—Killian's operation. A. Skin. B. Periosteum. C. Supraorbital portion. D. Infraorbital portion. E. Bridge.

**Killian's operation** gives the best results. In this operation the anterior wall and floor of the sinus are completely removed and the lining mucosa is extracted. The ethmoidal cells between the orbit and the nose must also be cut away so that a free communication with the middle meatus is established. The cavity produced is drained freely by gauze plugging brought through the nose, and a small external drain should also be inserted. The wound must be frequently irrigated until the suppuration has ceased. Owing to the preservation of a bridge of bone as shown in the figure (Fig. 306), deformity is slight in most cases.

**Infection of the sphenoidal sinuses.**—The sphenoidal cavities lie far back in the base of the skull above the posterior nares, and discharge from them passes directly into the back of the throat. The opening of the sphenoid can be reached by passing a probe directly backwards and upwards for 3 inches from the anterior nares across the centre of the middle turbinate bone. Chronic suppuration in this region is usually associated with disease of the posterior ethmoidal cells, and may give rise to copious discharge with persistent occipital headaches.

Dangerous complications may occur, such as retrobulbar neuritis, resulting in blindness, basal meningitis, and thrombosis of the cavernous sinuses.

*Treatment* consists in removal of the middle turbinate, free intranasal opening through the anterior wall of the sphenoid, and curettement of the posterior ethmoidal cells.

**Multiple sinusitis.**—Reference has already been made to this subject. When the inflammation involves all the accessory sinuses of the nose prolonged treatment may be necessary, and in most instances it is advisable to begin by draining the antrum. The middle turbinate and ethmoidal cells should next be treated. A third operation may be required to drain the sphenoid; or the fronto-ethmoidal and sphenoid cavities can be opened by a single external operation.

**Tumours of the nasal fossae and accessory sinuses.**—Innocent tumours are very rare, and include papilloma, fibroma (see *Naso-pharyngeal polypus*, p. 739), osteoma, adenoma, and myxoma. The diagnosis of such tumours can be made by careful examination of sections made after portions of the growths have been removed. In general they can be completely removed by intranasal operations. *Malignant tumours* are much more common. *Sarcomata* are met with both in children and in later life. All the known varieties may be found here—namely, fibro-sarcoma (common), round-celled, mixed-celled, myeloid, osteo- and chondro- sarcoma. The prognosis is very unfavourable except in the myeloid and fibrous forms. *Carcinomata* are common in two forms—namely, columnar-celled, probably originating in the ethmoidal region, and squamous-celled, from the antrum or front of the septum. The fact that both these types commence very frequently in the accessory sinuses, where they give rise to inflammation with copious purulent discharge, often results in their being mistaken for sinusitis; when they are occluded by mucous polypi, as often happens, early diagnosis may be especially difficult. In an elderly patient persistent unilateral discharge with pain and epistaxis must always be regarded with suspicion. Carcinomata in this region are locally malignant, but rarely affect the cervical glands or distant organs; the squamous form is much more serious, and recurs more readily than growths of columnar type.

Given sufficiently early diagnosis there is no doubt that certain types of malignant disease in the nose can be permanently cured. The growths must always be removed freely through an external incision; when situated in the ethmoidal region the upper part of the superior maxilla and the contents of the orbit may also require to be excised. Antral tumours can sometimes be eradicated without total removal of the jaw. Thus, the infraorbital plate or the palate can be preserved if either of them is found to be free from disease. In many instances the diagnosis of cancer is made too late, and the disease is found to be inoperable. In such cases radium in large doses and X-rays may give relief. The radium should be inserted into the middle of the growth and retained for twenty-four to forty-eight hours with the object of causing necrosis. In many instances two or more applications must be made. With radium treatment sarcoma or endothelioma may rapidly shrink or even disappear, and a larger operation can thus be avoided. With carcinoma this treatment is not so effective. All types should be kept under observation, as it is impossible to determine to what extent a radium cure will prove permanent.

## Surgery of the Pharynx.

**Pharyngitis.**—Acute inflammations of the pharynx may be caused by any pyogenic organisms, or may be traumatic and due to wounds, inhalation of

noxious vapours, steam, caustics and the like. In some instances the infection is known, and causes a definite clinical condition such as Ludwig's angina (due to *streptococcus pyogenes*). The onset of this disease is very sudden, and a healthy individual may be affected. The first symptom is soreness of the throat accompanied by symptoms of toxaemia, high fever, rigor, and rapid pulse. The pharynx becomes intensely swollen, and the patient finds that it is difficult to swallow. Within twenty-four hours the neck may be affected, with a brawny or œdematous thickening which tends to spread rapidly; œdema of the larynx may now supervene, causing sudden suffocation if tracheotomy is not performed. In the most severe types the patient may die in two or three days of acute toxæmia. In milder forms there may be suppuration in the cellular tissues of the neck, and there may be extension to the mediastinum, septic pneumonia, pleurisy, pericarditis or septicæmia.

*Treatment* must be energetic. Whenever available a large dose (50—100 mil.) of sensitised *streptococcus pyogenes* vaccine should be given, and repeated if necessary; an antistreptococcus serum or an intravenous injection (1—2 c.c.) of a solution of perchloride of mercury in normal saline (1—1,000) is strongly advised for the relief of toxæmia. Early incisions for relief of œdema or pus, tracheotomy when its desirability is indicated, and stimulating medicines to maintain the health are also important. In its most rapid forms the disease is extremely fatal.

**Diphtheria.**—The tonsils and fauces are by far the commonest site for infection with diphtheria. The Klebs-Loeffler bacilli, to which the disease is due, reach the throat in most instances by direct infection from person to person, by kissing and coughing, or by infected spoons, plates, etc. The accident is one which commonly happens at school, and in many instances the outbreak is difficult to explain unless a "carrier" can be found. An epidemic may also be caused by contaminated milk. There is no evidence that water is ever responsible, and defective drains are important only in so far as they inflame the throat and make the children more susceptible. It has been said that the disease may be caught from animals, but the evidence is scanty. A cat has been known to suffer from true diphtheria; in birds, however, the disease is of a different nature. Diphtheria commences gradually with malaise, lassitude, and a fever that seldom rises above 103° F. The throat becomes sore, and there is a swelling of the glands of the neck. In the early stages the inflammation is catarrhal, but before long a white, adherent membrane forms on the tonsils, fauces, and palate. Later there is albumen in the urine, and in very severe cases there may be vomiting and cardiac failure or paralysis. It may be quite impossible to diagnose diphtheria in its early stages, and suspicious cases should be isolated until a bacteriological report can be obtained. The surgeon must consider the advisability of antitoxin both for the patients and the contacts if these are children. He must remember that in pre-antitoxin days the mortality in diphtheria was 30 per cent.; now it is only 9 per cent., and not more than 3 per cent. with patients who get antitoxin on the first day of their disease. Further, he must not rely entirely on the bacteriologist. The two practical difficulties are, first, not to overlook the disease in its early stages, and, secondly, to decide upon a course of action in face of report notifying the discovery of Klebs-Loeffler bacilli when it is obvious that the patient is not suffering from diphtheria. The surgeon must use his discretion; but never let him imagine that he can always distinguish between diphtheria and other septic infections at the commencement of the disease.

*Treatment* (see *Laryngeal diphtheria*, p 750)

**Chronic pharyngitis** is a common affection, and the following forms have surgical importance :—*Septic*, which is due to the ordinary pyogenic organisms, as in cases of " hospital sore throat." *Syphilitic.*—The pharynx is frequently inflamed in both congenital and acquired syphilis and in all the stages of the disease. Kyle states that " next to the genitalia, the lips, tonsillar and pharyngeal sites are perhaps the most frequent seat of the primary lesion." During the secondary stages mucous patches on the pharynx and tonsils are still more common. Tertiary ulcerations may be very destructive, and are easy to recognise in most cases. The diagnosis must be made from Vincent's angina. In the latter there is generally a single punched-out ulcer on or near the tonsil, and the condition is always associated with the fusiform bacillus of Vincent and a long spirillum. *Tuberculous pharyngitis* is distinguished by its acutely painful, indefinite ulceration. *Lupus.*—Here there is a painless nodular infiltration of the palate and pharynx, with little tendency to ulceration. *Pharyngo-mycosis* is due to the growth of a mycelium or fungus which causes small white nodular masses adherent to the mucosa covering the tonsils, pharynx, and base of the tongue. Other rare conditions, such as actinomycosis and glanders, are also met with. Many cases of pharyngitis are caused by malignant ulcers, such as epithelioma, sarcoma and endothelioma (see p. 740).

FIG. 307.—Caries of the cervical spine producing a retropharyngeal abscess. (St. Bartholomew's Hospital Museum.)

**Adherent palate.**—This condition begins as a chronic inflammation of the pharynx, tonsils and fauces, and gradually results in fibrosis. The scar tissue steadily contracts until the opening from the naso-pharynx into the mouth is almost obliterated. The patient can breathe only through the mouth. He is unable to blow his nose. This leads to rhinitis and post-nasal catarrh. Deafness is liable to supervene, with other complications common in mouth-breathers. Very rarely the constriction is formed lower down in the pharynx, behind the base of the tongue. In one such case seen by the writer the stenosis of the pharynx was so marked that nothing larger than a probe would pass through it. The patient had been unable to breathe or swallow through the mouth for years. During this time he had lived with a tracheotomy tube for breathing and a gastrotomy wound for feeding.

Although this condition occurs with syphilis and simulates it in several respects, it is probably caused by some unknown infection. In some instances it begins after a simple operation such as the removal of tonsils and adenoids.

Adherent palate is extremely difficult to treat. Many operations have been suggested, but are rarely successful. Even after free excision of the scar tissue the stenosis quickly recurs, and dilating instruments are difficult to adjust in the back of the pharynx. It seems possible that better results will be obtained by diathermy (see also p. 658.)

**Retropharyngeal abscess** is a collection of pus in the loose cellular tissue behind the pharynx. It may be central or unilateral. Acute abscesses may be due to injuries caused by swallowing sharp-pointed bodies or acids, or to septic infections. They may occur during one of the exanthemata such as scarlet fever. In some cases no cause can be determined. Chronic suppuration may result from cervical caries, or from inflammation of the retropharyngeal glands, rarely by extension downwards from the mastoid or base of the skull. These abscesses are commoner in children than in adults, and are mostly due to infections with *staphylococcus aureus*. The symptoms are pain, variable in different cases; dysphagia; stridor or dyspnœa; swelling of the posterior wall of the pharynx, more difficult to see than to feel; and, with large collections, external fulness of the neck. With acute abscesses there is commonly febrile disturbance.

The *diagnosis* of retropharyngeal abscess is often difficult in early stages. In young children the symptoms may be similar to those which are caused by acute pharyngitis, œdema of the larynx, or even bronchitis. Again, the obstruction may be due to one of the solid swellings which are common behind the pharynx, such as tuberculous or syphilitic glands, lymphadenoma, endothelioma, carcinoma or sarcoma. Doubtful cases should be explored with a syringe.

*Treatment.*—Early incision should be performed. Large abscesses and collections known to be tuberculous may be opened by an external incision along the posterior border of the sterno-mastoid muscle. Other forms can be opened safely through the mouth. If a general anæsthetic is given, the patient should be in the lateral position so that the pus does not enter the larynx. After free incision through the mouth the healing is generally rapid.

## The Tonsils.

The upper part of the pharynx contains a ring of lymphatic or gland tissue which is massed together at four chief points. These are the faucial tonsils laterally, the pharyngeal or Luschka's tonsil (adenoids) above, and the lingual tonsil in front on the base of the tongue. Similar gland tissue occurs in the sides of the larynx and is known as the laryngeal tonsil.

**Acute tonsillitis** is caused by inhalation of pyogenic organisms, the commonest infection being *streptococcus pyogenes*. The inflammation may be superficial (catarrhal), or in the gland tissue (parenchymatous), or in the crypts (follicular), and is always associated with pharyngitis. It affects people in all conditions of life and at any age, whether "run down" or in perfect health. Children are especially susceptible. Outbreaks are common in schools, in houses where the ventilation or drainage is imperfect, and in hospitals ("hospital sore throat") on account of person to person infection. Tonsillitis also occurs during the exanthemata such as measles, scarlet fever or diphtheria (see p. 731). The attacks are often recurrent. The onset is always sudden and commences with a fit of shivering or rigor, with high temperature to 104° or 105° F. The symptoms of "sore throat" are well known—namely, furred tongue, offensive breath, salivation, pain darting to the ear and increased on swallowing, with swelling of the glands below the angle

of the jaw. If the mouth can be opened, one or both tonsils will be found to be red and swollen; the fauces are covered with mucus, and yellow plugs may be seen in the crypts. The inflammation may subside in three or four days, or terminate in an abscess. Even in the most severe forms, it rarely leads to a general blood-poisoning.

*Treatment.*—A free purge should be given, also quinine and salicylate of soda internally. For catarrhal inflammations, antiseptic inhalations and a steam kettle are recommended. In follicular cases the tonsils should be painted with izal (♏ xv. ad ʒi.) or the patient made to gargle with potassium permanganate (gr. $\frac{1}{8}$ ad ʒi.). External fomentations or a dressing of "antiphlogistine" will also give relief. When the pain is very severe an anodyne such as aspirin, or even morphia, may be necessary.

**Abscess.**—Suppuration may be tonsillar or peritonsillar, the latter being the characteristic "quinsy." The development of an abscess is attended by malaise, continued fever, intense pain, tenacious mucus, and swollen glands. The pus usually forms behind the upper part of the tonsil, and causes a swelling of the supratonsillar fossa, which extends forwards along the palate. As it is rare for an abscess to burst in the early stages, a swelling of this kind should be explored. The older method of cutting a quinsy through the palate with a knife should be abandoned. It is better to apply a solution of cocain (20 per cent.) and then break through the supratonsillar fossa or tonsil with a right-angled probe. The probe can be passed boldly in different directions without causing great pain. If pus is found, the opening should be dilated with sinus forceps. If not, the patient still may be relieved after the escape of serum from the puncture, or the operation can be repeated on the following day. Once the abscess has been drained recovery is generally rapid.

**Chronic tonsillitis** is also due to a variety of causes, and in children is common in association with adenoids. When a tonsil has been inflamed for a long time, either it becomes enlarged or its crypts are distended with a secretion composed to a great extent of virulent organisms. The effects produced vary in different cases. Thus enlargement of the tonsils and adenoids may be sufficient to cause nasal obstruction and mouth-breathing. Septic discharge leads to catarrh in the nose, pharynx, and lower air-passages, and results in colds, Eustachian deafness, recurrent tonsillitis, pharyngitis, laryngitis, or bronchitis. Infections of the alimentary canal also may be due in many instances to swallowing such discharge. Septic absorption causes swelling of the glands and general ill-health. This is favourable to *infection with tubercle bacilli.* It is now generally recognised that tubercle bacilli gain an entrance to the cervical lymphatics through the tonsils, thus causing "tuberculous glands in the neck"; also that they may pass through the cervical lymphatics to the bronchial glands and be carried to the lungs, this being one of the modes of infection in phthisis. Reflex effects are also commonly caused by tonsillitis, such as cough, vomiting, night terrors, convulsions and chorea. In all forms of rheumatism the possibility of tonsillar sepsis should be remembered.

The *symptoms* of "tonsils and adenoids"—namely, the peculiar vacant expression; mouth-breathing (snoring at night); the noises that are made when the patient swallows; the tendency to colds, sore throats, earache and deafness—are so well known as to make the condition easy to diagnose, and when such symptoms are present there is usually a definite hypertrophy of the tonsils or adenoids, or both. But it is not the size which determines the treatment, for mild degrees of nasal obstruction can often be cured by proper attention to the general health, with fresh air and breathing exercises.

It is only when serious symptoms have developed, such as those referred to above, that the tonsils and adenoids must be removed.

*Operative treatment.*—There is a popular superstition that an operation in the throat is a dangerous undertaking, and to some extent this is supported by facts. The two chief dangers are the anæsthetic and hæmorrhage. The anæsthetic is difficult to administer because of the abnormal condition of the pharynx. A tumour, or enlargement of the tonsils, may cause no obstruction to respiration under normal conditions; but given an anæsthetic, the patient may be in serious danger of losing his life from suffocation caused by falling-back of the tongue, spasm of the glottis, or by mucus or blood blocking the air-passages, and heart failure. These accidents are much more common in young children and when chloroform is used. Recently A. L. Flemming has collected 700 cases of deaths from anæsthetics reported in the lay press in four years, and 378 of these were caused by chloroform. It is high time that the medical profession recognised the danger of anæthestics and gave up ascribing the deaths to status lymphaticus. The importance of a skilled anæsthetist and light anæsthesia is paramount. Chloroform alone should never be used. Open ether or gas and oxygen are greatly to be preferred.

*Hæmorrhage* during throat operations is often free, but rarely dangerous if care is taken that the blood does not enter the larynx. The importance of the position of the patient in these operations, a matter referred to time after time by the late Sir Henry Butlin, has never received as much attention as it deserved. Without doubt Butlin is right, and the best position is for the patient to lie on his side on a flat table, so that the blood runs out of the mouth. Under these conditions the work of the anæsthetist is easy because respiration is not impeded. Sudden bleeding, whatever its source, can always be controlled by direct pressure with a sponge; and when the pharynx is freed of clots a spurting vessel can generally be seized with forceps and ligatured. Given sufficient experience, these operations are not dangerous; but one must always be prepared for the unexpected, and ready to perform tracheotomy at any moment if the patient cannot be made to breathe.

**Removal of adenoids.**—This operation is generally performed with a mild degree of anæsthesia. It can be completed rapidly with a modified Gottstein's curette, or more slowly by use of Loewenberg's or similar forceps. Care should be taken that the curette is kept exactly in the middle line, so that the Eustachian openings are not damaged; also that the adenoids are not partially detached and left hanging in the pharynx as a tag; lastly, that removal is as thorough as it is possible to make it. The nose should also be examined, because in some cases it is necessary to remove a portion of the inferior turbinates in order completely to relieve the nasal obstruction. No local after treatment is necessary.

**Removal of tonsils.**—This operation may be performed with or without a general anæsthetic, and when adenoids are present they should be removed at the same sitting. In some instances it is necessary to cut away only a part of the tonsil (tonsillotomy); in other cases the whole gland should be removed with its capsule (tonsillectomy). The present trend of opinion is towards the view that there are very few cases which can be cured by tonsillotomy; but tonsillectomy, which is a more serious operation, should be reserved for cases in which a radical operation is essential, such as submerged, adherent, or grossly-diseased tonsils, tuberculous and malignant growths. On the other hand, in people who are known to bleed easily, a cutting operation may not be advisable; in such cases the tonsils can be more safely destroyed by diathermy.

**Tonsillotomy** (with cocain or novocain).—This may be performed with any guillotine preferred by the surgeon. At the moment of cutting, the tonsil must be firmly pushed inwards by an assistant pressing on the neck so that as much as possible projects into the instrument. By using two guillotines both tonsils can be removed simultaneously.

**Tonsillectomy** (general anæsthesia preferred).—This may be performed with a blunt guillotine by "Sluder's method," or by dissection. With the former it is certainly possible in the majority of cases to remove the entire tonsil with its capsule, but considerable experience is required. As a rule it is advisable to operate by dissection, since this method is more reliable and requires very little more time. A strong reflected light is essential, and there should be a competent assistant to depress the tongue and help

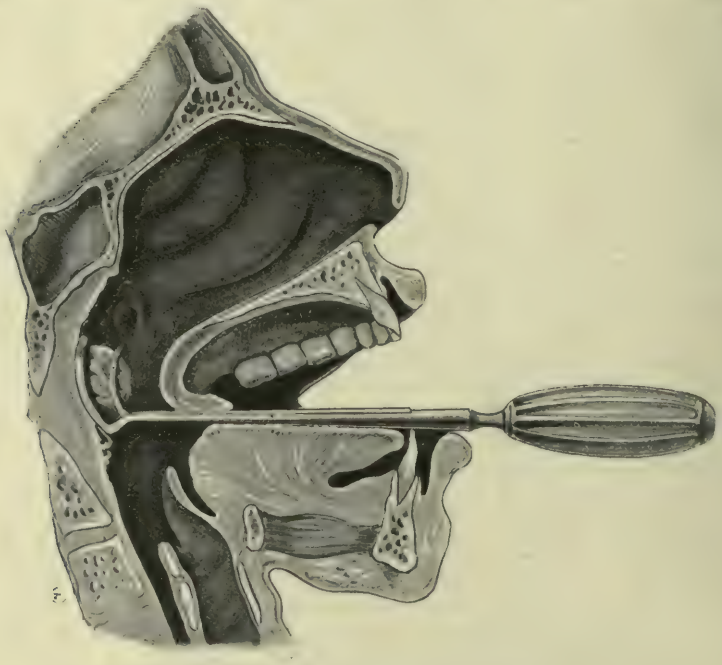


FIG. 308.—Removal of adenoids with curette.

with sponging. The tonsil is firmly gripped by a tenaculum forceps and drawn downwards and inwards, so that the mucosa under the arch of the fauces can be torn with a blunt periosteal elevator. The tear should include the mucous membrane only, and should be continued for a short distance along the anterior and posterior pillars of the fauces, taking care not to injure the latter. The upper pole of the tonsil can then be dislocated out of its fossa by downward traction with the tenaculum, and the whole gland can be rapidly removed by a strong wire snare (Fig. 309). When the operation is properly performed the tonsil will be removed intact. If a portion has been left behind the snare can be used again. The cavity should be immediately plugged with a sponge twice the size of the tonsil, and pressure maintained for several seconds. The wound is then carefully searched for bleeding vessels, which, if necessary, can be picked up and tied or twisted. After sponging the throat the second tonsil is removed in a similar manner.

When removing a cancer of the tonsil through the mouth the dissection takes much longer, and only the final stages can be completed with the snare.

Tonsillectomy may be a difficult operation, but, if properly performed, rapid healing is obtained in the majority of cases, and no special after treatment is necessary. The chief complication to be feared is *hæmorrhage*, which may occur during the operation or later. At the time it is rarely alarming: if venous, it often yields to pressure; when arterial, the vessel should be tied. Bleeding which continues for some hours after the operation

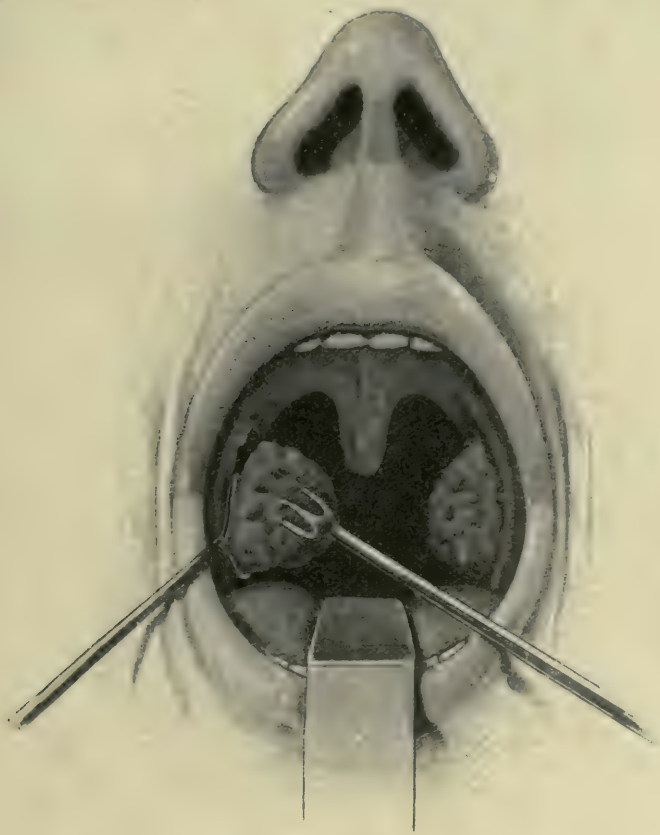


FIG. 309.—Tonsillectomy with snare.

is more serious. In children it may not be suspected because they swallow the blood into the stomach. After a time, however, they become faint and vomit, expelling a mixture of dark-brown blood and gastric juice. In adults the hæmorrhage is more easily detected. This condition must not be confused with the recurrent hæmorrhage which may occur six to twelve hours later, especially as the result of vomiting. With the latter there is generally a sudden spitting of bright-coloured blood, often so copious as to drench the sheets of the bed. True secondary hæmorrhage about the eighth day is fortunately rare.

Persistent bleeding from a tonsil is always a serious matter. Those who are unfortunate enough to meet with a case, however, should remember that

fatalities are very uncommon, because the bleeding ceases when the patient becomes faint. The deaths that have occurred have been mostly due to sudden arterial hæmorrhage, and not to long-continued oozing from the veins.

*Treatment in case of bleeding* should proceed on the following lines:— The patient should be propped on a pillow and told to keep quiet; ice may be sucked, or cold applications may be made to the neck and face. If the bleeding continues and is severe, direct sponge pressure should be applied at once to the wound and maintained for five to ten minutes whether the patient likes it or not. If this fails to arrest the hæmorrhage, a gauze dressing should be stitched into the tonsil fossa, the pillars of the fauces being sewn together in the process. This operation can be rapidly accomplished by using the special Michel's clips made for the purpose. If sutures are used a general anæsthetic may be necessary, particularly with a child. The direct treatment of the wound is much to be preferred to ligature of the external or common carotid, for cases have been recorded where, although the carotid had been tied, the bleeding continued until the patient became faint. For general oozing which has persisted for long periods subcutaneous injections of serum are advised, and shock should be combated by repeated salines in the bowel or into a vein.

**Tumours.**—Tumours of the tonsil are generally malignant, and papilloma is the only innocent form that affects it (see p. 739). Two forms of cancer are met with, namely, squamous-celled carcinoma, common in men over fifty, and small round-celled sarcoma in both men and women over thirty (males being rather more subject to it than females). An epithelioma forms an indurated ulcer with hard everted edges, not strictly limited to the tonsil but tending to invade the palate, pharynx, and tongue. In many cases the tongue is fixed and cannot be protruded; later the patient finds a difficulty in opening the mouth and in swallowing. The jaw-bones may become involved. Such growths are generally associated with early enlargement of the glands, and may give rise to neuralgia of the side of the neck, ear and head, which in many instances cannot be relieved. The removal of these tumours is usually effected through the mouth by an operation similar to enucleation of the tonsils, and in every case the glands must also be removed by free dissection of the anterior and possibly the posterior triangles of the neck. Removal of a tumour from outside by lateral pharyngotomy is also undertaken occasionally. The latter operation is a much more serious one, and is attended with grave risks. So-called inoperable cases can often be relieved by diathermy.

Sarcoma begins as a unilateral enlargement of the tonsil, and rapidly increases in size, displacing the palate and fauces in turn; in the later stages ulceration and sloughing may occur. The disease spreads to the glands of the neck at an early date, and is very prone to dissemination in other parts of the body. As the late Sir Henry Butlin wrote: "The tendency of sarcoma to early and extensive metastasis renders the prognosis very unfavourable. The best results are to be expected in the case of an epithelioma of limited extent when the primary disease and the glands have been widely removed." To this might be added the very rare cases of spindle-celled sarcoma and endothelioma which occasionally affect this region (see p. 740). For round-celled sarcoma radium is better than the knife. The radium (1—2 milligrammes) should be enclosed in a thick tube of platinum or silver and buried in the centre of the tumour, where it is retained for one or two days. In many instances recovery is complete in a few weeks.

## Tumours of the Pharynx.

Innocent forms are so rare that only two are worthy of mention, namely, *papilloma*, generally seen on the tonsil, and the only non-malignant neoplasm that ever occurs there, and *naso-pharyngeal polypus*. This latter growth is a fibro-angioma which springs from the periosteum of the basillar process of the occipital bone, the body of the sphenoid, and the root and outer wall of the nose. Such a tumour is sessile or broadly pedunculated, and consists of dense fibrous tissue mixed with spindle cells and large vascular spaces. The mucosa covering it may also be very vascular. As it increases in size it invades and displaces the bones, making a new cavity in which it lies. In the process of its formation the nose, antra, pharynx, and base of skull are all encroached upon. In the worst cases there is the characteristic deformity known as "*frog-face*." These tumours usually occur in young males between the ages of fifteen and twenty-five. They show an inveterate tendency to hæmorrhage, and bleeding may be the first and only symptom; sometimes it is very severe, and it may even be fatal if the tumour is not removed. With large growths there is nasal obstruction, a thick, dead voice, deafness, a tendency to sleepiness, and, rarely, a foul discharge.

*Treatment.*—The removal of these growths may be attended with such profuse hæmorrhage that the life of the patient is endangered. Even in small tumours it is safer to perform a preliminary laryngotomy and plug the pharynx firmly with a marine sponge. Growths which are chiefly confined to the naso-pharynx should be taken out through the mouth. The operation is comparatively easy after splitting the soft palate; if more room is required, part of the hard palate also can be cut away after reflecting the muco-periosteum (Nélaton's operation). On the other hand, special instruments have recently been devised with which it is possible to perform the operation without any division of the palate, marking a distinct improvement in the surgery of these cases.

Large growths which encroach on the nose should be removed by an external operation, such as lateral rhinotomy, or Moure's operation (nose turned to one side); Rouge's operation (turning the nose upwards by an incision under the upper lip); Langenbeck's operation of temporary resection of the maxilla (the jaw turned outwards and replaced when the growth has been removed); partial resection of the upper jaw; or a modification of these methods. The first two operations mentioned above are much to be preferred, since they give an excellent exposure of the naso-pharynx and do not result in noticeable scarring. With lateral rhinotomy the writer easily removed a very large pulsating "frog-face" tumour after preliminary laryngotomy and temporary ligature of both external carotid arteries with Crile's clamps. As soon as the growth has been freely exposed it should be rapidly torn away with a raspatory introduced under the periosteum. The whole tumour must be taken away, including, if necessary, a part of the base of the skull. When the dura mater is involved the brain itself should be exposed. After the removal of the tumour there remains a rounded cavity, which should be immediately plugged with gauze to arrest the bleeding. In the majority of cases it is advisable to leave the packing untouched for forty-eight hours. If the palate has been divided the opening must be repaired with sutures.

The after-treatment for hæmorrhage and shock must also be carefully considered. Small naso-pharyngeal polypi have been successfully treated by electrolysis; diathermy is also suitable in certain cases.

The prognosis in these cases depends upon the character of the growth, and a section should be made to determine whether it is a true fibro-angioma or

contains sarcomatous tissue. The former class is non-malignant, but may recur locally, especially if incompletely removed.

**Malignant tumours** are comparatively common, and give rise to different symptoms according to their position in the pharynx. In the post-nasal space they cause nasal obstruction, post-nasal discharge, deafness or earache, and pain. In most cases the symptoms are very indefinite in the early stages of the disease, so that the patient does not realise that there is any serious trouble. Tumours of the tonsil or deeper in the pharynx also produce few symptoms at first. The majority of patients who complain of pain in their throats which they believe to be caused by a " cancer " are found to be suffering from abnormal sensations (*paræsthesia pharyngis*) due to over-anxiety or worry. Only when the disease is far advanced and the glands of the neck are enlarged is there any complaint of dysphagia, blood-spitting, or difficulty in breathing. Hæmorrhage, however, may occur at an early stage, and is therefore of great importance. The early diagnosis of cancers in the pharynx is very difficult. As soon as a tumour is discovered a portion of it should be removed for microscopical examination.

**Carcinomata (squamous-celled)** are common in men over fifty, and may commence in the naso-pharynx, in the tonsil (see p. 738), or near the larynx (see p. 754). Most cases of naso-pharyngeal cancer are inoperable because they are discovered too late, and because it is impossible to remove them completely on account of their position. Even when freely removed recurrence is liable to occur. Temporary relief may sometimes be afforded by diathermy.

**Sarcomata** are also common in the naso-pharynx and tonsils (see p. 738), and are seen in young adults. The results of operation are very unfavourable, as the glands and distant organs soon become affected. A rapid disappearance of these tumours may result from energetic treatment with radium, but it is still doubtful whether the " cures " will be of long duration. Whenever possible the radium should be buried in the growth.

**Endotheliomata.**—Cases of endothelioma are by no means rare, starting in the wall of the pharynx behind the tonsil or higher near the Eustachian tube. The latter cause deafness, and the former a displacement of the tonsil across the middle line. Such tumours are generally palpable in the neck behind the angle of the jaw. In rare instances they can be completely removed through the mouth or enucleated by an external incision through the neck. In most cases they are quite inoperable. They soon invade all the neighbouring tissues, and the prognosis is very unfavourable, although they can often be checked by radium.

**Diathermy.**—Diathermy is useful for the destruction of inoperable cancers in the mouth or pharynx, including growths of the palate, tonsil, tongue, post-nasal space, and pharynx ; for certain innocent tumours of the same regions or enlarged tonsils, when it is thought that a bloodless operation is advisable ; for vascular nævi of the tongue or pharynx, or of the skin of the nose or face ; for lupus ; and for the removal of scar tissue such as occurs with adherent palate. A general anæsthetic is required. The apparatus consists of a motor which produces a high frequency current of great power, and two electrodes, a large one, which is wrapped in wet towels and laid on the patient's chest, and a small one made of metal, which is plunged into the growth. The passage of a strong current through the small electrode produces intense heat, which rapidly destroys the tissues. When operating upon a growth in the mouth it must be sponged quite dry. The small electrode is plunged into the tumour and the current turned on for five to fifteen seconds, by which time

the neighbouring tissues are necrosed. For large growths it is advisable to use an electrode like a small rake, with ten or more short teeth, and as soon as the parts have been coagulated they should be scraped away with the rake or a sharp spoon. In this manner it is possible to effect a thorough removal, and very little sloughing results. Such an operation can be completed in ten to fifteen minutes. There should be no loss of blood even with vascular tumours. Afterwards the pain is slight and rarely persists for more than two days, at the expiration of which period the patient generally can leave his bed. He can swallow well in twenty-four to forty-eight hours. The surrounding tissues do not become much inflamed, and there is no œdema such as occurs after burning with the galvano-cautery. The sloughs separate in about ten days, leaving a healthy wound without discharge and without scar tissue. Secondary hæmorrhage is unlikely to occur. For the destruction of very extensive ulcers two or more applications may be necessary. The advantages of this treatment are—the rapidity of the operation, the possibility of removing a dangerous growth without loss of a single drop of blood, and the fact that the vessels and lymphatics are sealed by the burning. There is no evidence that cancer cells are more easy to kill than normal tissues, but it is possible that recurrence is not so rapid as after cutting operations.

**External operations.**—Pharyngotomy is an operation which is usually performed for the removal of a malignant growth. It is rarely necessary for impacted foreign bodies, since the latter generally can be broken up and removed by Killian's tubes.

*Median pharyngotomy* is performed when the opening is made through the thyro-hyoid membrane. A vertical incision through the skin is better than a transverse, because the sutures are less likely to cut out and leave an open wound. This operation gives an excellent exposure of the pharynx, and is suitable for excision of growths involving the epiglottis and base of the tongue.

*Lateral pharyngotomy* gives a much better exposure of tumours at the side of the pharynx. The incision is made along the anterior border of the sterno-mastoid muscle and is carried into the pharynx in front of the carotid vessels. In most cases the lymphatic glands are removed before the pharynx is opened, and ligation of the external carotid may also be necessary.

Before either of these operations preliminary laryngotomy should be performed.

## Surgery of the Larynx and Trachea.

### Examination of the Larynx, Lower Air Passages, and Œsophagus (see also p. 758).

**Indirect examination.**—To obtain a satisfactory view of the larynx a strong reflected light and a darkened room are essential. The patient's mouth must be opened to the greatest extent, and the tongue must be drawn well forwards (not downwards on to the teeth) and held by the surgeon's left hand. A mirror, having been properly warmed, is applied to the soft palate so that the uvula is pressed firmly and steadily backwards and upwards against the posterior wall of the pharynx. The epiglottis should at once come into view; and, with a little practice, the arytenoid cartilages, vocal cords, ventricular bands, ventricles and lateral ary-epiglottidean folds can be inspected in turn. To gain a better view of the glottis, and to note whether there is normal movement of the cords, the patient should be instructed to say "eh" and then to take a long sighing breath.

The above method is still the ordinary routine examination of the larynx.

It being essential that the patient should be tolerant, the operation is chiefly applicable to adults; but a momentary view of the larynx can generally be obtained by this means even in children. The employment of cocain or novo-

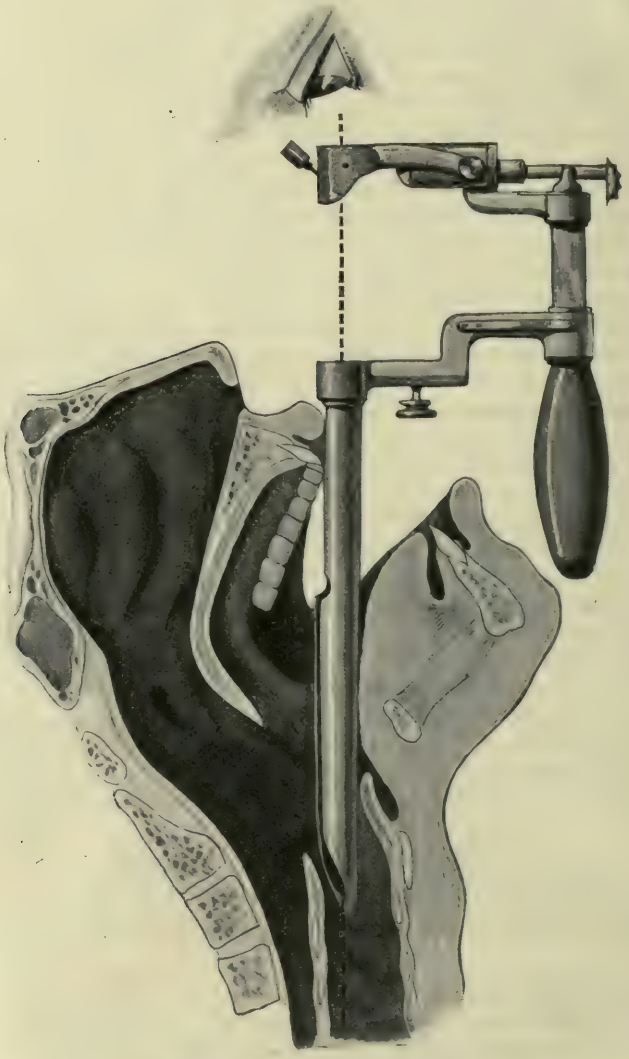


FIG. 310.—Direct laryngoscopy.

cain (10 per cent. solution) is often of the greatest importance to both surgeon and patient.

**Direct examination.**—With the direct method it is possible to make an accurate examination of the larynx (laryngoscopy), trachea (tracheoscopy), bronchi (bronchoscopy), and œsophagus (œsophagoscopy) (see p. 759). The apparatus required is complicated and can be used safely only by those who are accustomed to the work. The operation may be performed with local or general anæsthesia, with the patient sitting on a low stool or lying on a table.

The tubes should be passed by sight, and this must be done with great gentleness, or serious injuries may result. When chloroform is employed it is the duty of the anæsthetist to note that normal respiration is maintained; and the necessity for tracheotomy or artificial respiration must always be borne in mind.

Direct methods are also useful for the treatment of foreign bodies, strictures and innocent tumours in the air-passages and œsophagus.

## Diseases of the Larynx.

**Foreign bodies.**—Accidental inhalation of foreign bodies is more common in children than in adults. The inhaled bodies may be divided into three classes:—*Pointed*, such as bones, needles, nails or teeth: *rounded*—hard, such as coins, stones, and buttons; or soft (in some cases capable of swelling), such as meat, beans or peas: *fluid*, such as blood, pus, or vomited food. The situations at which they become arrested vary with the nature of the body. Whereas pointed objects are often caught in the mucous membranes of the pharynx, larger bodies, such as tooth-plates and coins, are commonly arrested in the œsophagus. Any of the articles referred to above, however, may become impacted in the larynx or trachea or fall into the bronchi. If a foreign body is not removed, it may either become loosened by inflammation and be expelled by the mouth or pass into the stomach, or it may cause an ulceration leading to perforation and septic infection of the neck, mediastinum, pleural cavity, or pericardium. In rare instances the patient may die from general blood-poisoning without perforation, or from hæmorrhage owing to implication of a large blood-vessel. It has been estimated that the mortality of all foreign bodies in the air-passages was 33 per cent. before the introduction of Killian's tubes. Now it is very much lower (see p. 745). The symptoms and treatment vary according to the nature, size, and position of the foreign body.

1. *In the pharynx.*—A large piece of meat arrested near the entrance to the larynx will give rise to urgent dyspnœa or suffocation, and an endeavour should be made to remove it instantly with the finger. This is very important in children, in whom other substances, such as thickened mucus, can often be dislodged. If this method fails, the child should be inverted and slapped smartly on the back. It should be remembered that in children the dyspnœa is rarely so urgent as to necessitate an operation, but when no relief is obtained tracheotomy must be performed, and artificial respiration if natural breathing does not commence at once. For adults laryngotomy is a quicker and simpler operation than tracheotomy, but in children the crico-thyroid space is so small that it is impossible to introduce a tube without division of the cricoid cartilage. A fish-bone or pin may be impacted in any part of the pharynx, such as the tonsils, base of the tongue, fauces, or across the larynx. It causes a pricking sensation, with pain and difficulty in swallowing. The patient is often able to indicate the position of the foreign body, but it may be difficult to see. It must not be forgotten that the symptoms may persist after the bone has disappeared, in consequence of an injury to the mucous membrane. When present, it can be removed by being hooked out with the finger or with suitable forceps or hooks.

2. *In the larynx.*—The body may be lodged above, below, or between the vocal cords, or in the ventricles. The symptoms are often alarming. The patient begins to gasp for breath, or choke. If the body is large respiration may be completely obstructed, and the face congested, and death may result

before relief can be afforded. In less severe cases there may be repeated spasms of hoarse cough, with loss of voice, stridor, and dyspnœa in some degree.

3. *In the trachea or bronchi.*—The symptoms vary according as the body is free or impacted. If loose, there may be paroxysmal attacks of suffocative cough and dyspnœa, because the foreign body is driven up and down the trachea, prevented from escape by spasm of the glottis. When impacted, it may lie in the trachea or, more often, in the bronchus. The right bronchus is affected oftener than the left owing to its larger size, its direction, which is more nearly that of the trachea, and the inclination of the septum to the left of the middle line. Gottstein states that in men the foreign body enters the right bronchus in four cases out of five, and in women in two out of three.

The *symptoms* of this condition are deficient movement and retraction of the affected side of the chest, with alteration of breath sounds and of vocal fremitus. Resonance is first normal and later dull: these signs vary according to the position and nature of the body, and the completeness or incompleteness of the obstruction of the bronchus or one of its branches. In rare instances there may be complete collapse of the lung; on the other hand, even large foreign bodies may enter a bronchus without causing definite symptoms, and may remain there for many years. In other cases a foreign body induces chronic changes in the lungs, such as bronchitis, bronchiectasis, pneumonia, abscess or gangrene of the lung, or empyema, and makes the patient seriously ill. Under such conditions there is usually a paroxysmal cough, with expectoration of offensive sputum, and hectic fever. Although sudden death may occur during an attack of spasmodic dyspnœa, the common termination is due to septic broncho-pneumonia.

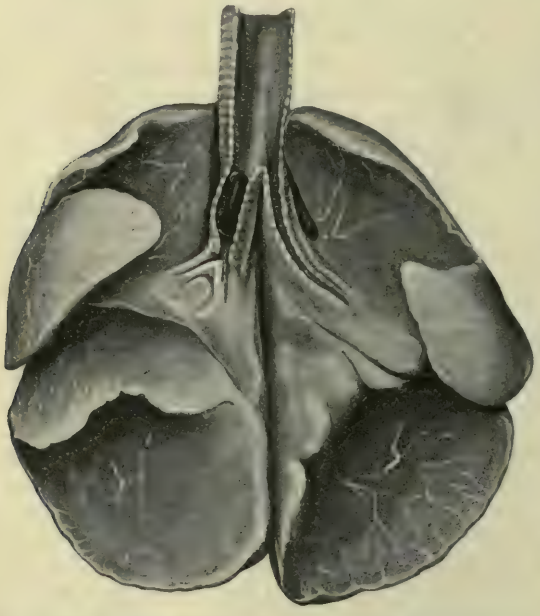


Fig. 311.—Foreign body in bronchus. (St. Bartholomew's Hospital Museum.)

The *treatment* of foreign bodies in the lower air-passages varies according to the nature, the size, and the position of the inhaled substance. Whenever possible, radioscopy should be undertaken in order to determine the position of the body, and to make certain that it lies in the air-passages and not in the œsophagus. Secondly, since urgent dyspnœa may supervene at any moment, the surgeon must be always prepared for tracheotomy. The actual removal of the inhaled body is generally effected by direct laryngoscopy, tracheoscopy, or bronchoscopy, since they give far better results than the older methods of treatment, such as inversion, emetics, tracheotomy, thyrotomy, and broncho-

tomy. With the last-named operations about 41 per cent. of the cases were fatal. Since the introduction of bronchoscopy this mortality has been steadily lowered as the result of improvements in the instruments and technique. Recently Chevalier Jackson has published an analysis of 628 cases with successful extractions in 98·1 per cent. and a mortality of only 1·9 per cent.

In *upper bronchoscopy* the tubes are passed through the mouth and larynx. If the operator be experienced, this can be performed without endangering the patient's life even in the case of a young child, but great gentleness is necessary in order to avoid injury to the larynx.

*Lower bronchoscopy.*—Preliminary tracheotomy having been performed, a wider tube can be introduced through the opening in the trachea. This method has certain advantages. Being easier to perform, the surgeon needs less experience; the wider tube is more easily illuminated; there is less danger of asphyxia; in late cases with marked expectoration it is often preferable; and in all cases with urgent dyspnœa it is practically essential.

4. *In the œsophagus.*—Foreign bodies, such as tooth-plates, coins, and sharp-pointed objects, may be impacted below the cricoid cartilage, at the bifurcation of the trachea or above the cardiac orifice; in most cases they are arrested above the bifurcation of the trachea at the level of the upper opening of the thorax. The symptoms vary according to the size of the body and the length of its stay in the gullet. There is usually pain, or sensation of pressure, which is increased with the action of swallowing. The patient may be able to localise the position of the body, and may point to the neck or the epigastrium; but the symptom is unreliable. Dysphagia varies greatly, and may be due to pain, spasmodic contractions, or to the size of the body. It must not be forgotten that a small piece of sharp bone may set up so much inflammation of the mucosa after a few days that the lumen of the œsophagus is completely closed and nothing can be passed into the stomach by patient or surgeon.

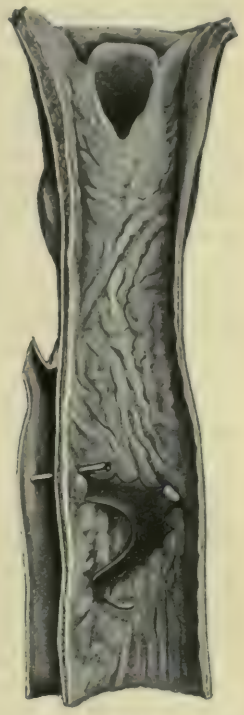


FIG. 312.—Tooth plate impacted in œsophagus ulcerating into the aorta. (St. Bartholomew's Hospital Museum.)

Regurgitation of food and retching are common with severe forms of obstruction; when the occlusion is high up the food is vomited immediately after swallowing, but there may be considerable delay when the lower end of the gullet is blocked. In the latter instance the patient may appear to swallow even a large quantity of water with ease, but he can feel that it has "stuck" and has not passed into the stomach. Dyspnœa is not so common, but may occur (especially in children when the foreign body is in the neck) from pressure on the back of the trachea. Expectoration of blood and mucus may occur in old-standing cases. Pointed bodies are liable to perforate the wall of the gullet and give rise to swelling of the neck, pleurisy, or mediastinitis, according to their position. The early diagnosis of foreign bodies in the œsophagus is most important, but often presents great difficulties. Careful attention must be paid to the history given by the patient or parent, and

every doubtful case should be submitted to a thorough examination. Delay may be disastrous.

Before undertaking the examination of such a case the surgeon must be satisfied that the foreign body has been swallowed. He must then attempt to decide whether it has been vomited or passed into the stomach, remembering that hard bodies, such as plum stones and bones, when passing through the gullet, may injure it sufficiently to cause sensations lasting for weeks or even months, especially in nervous females. The nature of the body is also important. If composed of metal or certain forms of rubber it can always be located by radioscopy, though other substances, including bones, can be detected but rarely in this way. The fact that a bougie may often pass by a foreign body easily may be very deceptive; even when felt, the sound is of little value, as it is wrong to attempt to displace the body downwards towards the stomach for fear of injuring the gullet. Probangs, coin-catchers, and similar instruments are dangerous and should never be used, except for fish bones known to be small and soft; œsophagoscopy is the operation of choice, and should be practised whenever possible. Even large tooth-plates can be broken up and removed in pieces through a tube; and open safety pins can be closed and then extracted harmlessly. In skilled hands accidents are uncommon, though they may occur during the removal of sharp-pointed bodies from an inflamed and weakened œsophagus.

*External operations*, such as lateral pharyngotomy (see p. 741) and œsophagotomy (see p. 769), should be reserved for late cases in which there is severe inflammation of the œsophagus, or of the surrounding tissues, with signs of cervical cellulitis or mediastinitis. As Bruenings shows, the mortality of œsophagotomy (12 to 20 per cent.) is ten times greater than that of œsophagoscopy.

**Injuries of the neck.**—Cut throat and other wounds are rarely accidental, but are generally inflicted with suicidal or homicidal intent. They may be in any situation between the chin and the sternum, but, on account of its prominence, especially across the thyroid cartilage. There may be one or more gashes, with chipping or partial fractures of the cartilages. The incision may extend to the front of the vertebræ, but the larger vessels often escape. Lateral wounds are less common, but more fatal, since they often injure the carotid artery or jugular vein. Posterior wounds are very rare, though a suicide, by a transverse cut with a razor, has succeeded in opening the spinal canal between the occiput and atlas. The character of the wound alone is a very uncertain guide in determining its origin, whether homicidal, suicidal, or accidental.

A wound above the hyoid may sever the tongue, the muscles that depress the jaw and elevate the hyoid, the lingual and facial arteries, or the hypoglossal nerves. Such a wound gapes widely and food and saliva may escape from the mouth. When the cut divides the thyro-hyoid membrane, the commonest form of cut throat, the pharynx is exposed, and the epiglottis, ary-epiglottidean folds, arytenoid cartilages, the superior thyroid or lingual arteries, and the superior laryngeal nerves may be wounded. There is usually marked dysphagia, and saliva escapes through the opening. A wound through the thyroid cartilage may injure the vocal cords and occasion permanent injury to the voice. Hæmorrhage is usually slight. When the wound is below the cricoid, the infrahyoid muscles, the inferior or superior thyroid arteries, the anterior jugular and thyroid veins, and the recurrent laryngeal nerves may be divided, the last causing paralysis of the vocal cords. The trachea may be partially or completely severed, and even the œsophagus cut. A few cases

have also been reported of total laryngectomy by suicides. Whatever the position of the wounds, the carotid arteries owe their escape to the resistance of the cartilages of the larynx, their deep situation when the head is thrown back, and the contraction of the sterno-mastoid muscles. The sheaths or outer coats may, however, be nicked. With bullet wounds and stabs any of the structures in the neck may be affected. The immediate danger is hæmorrhage. When the carotid artery or internal jugular vein is opened, death may or may not be instantaneous. Even if no large vessel has been implicated, death may occur before help is obtained, from dyspnœa caused by blood in the trachea, lolling back of the tongue over the glottis, the displacement of the fractured cartilages, or the retraction of a divided trachea. Entrance of air into the veins is also an occasional cause of death. The subsequent complications are—œdema of the larynx; bronchitis or septic pneumonia; cellulitis, with extension of the inflammation to the mediastinum or pleura; septic or traumatic fever; secondary hæmorrhage; surgical emphysema; the formation of granulation or scar tissue, causing stenosis of the larynx or trachea, with dyspnœa and aphonia; œsophageal or tracheal fistula.

*Treatment.—Hæmorrhage* must be treated immediately. Large vessels, such as the carotid, must be compressed by the fingers forcing the vessel against the front of the vertebræ. As soon as possible a free incision should be made, and the vessel explored and tied both above and below the wound. When the sheath or outer coat alone is involved, fine sutures can sometimes be inserted to repair the injury. Smaller vessels can be picked up with forceps and tied. The treatment of secondary hæmorrhage should be conducted on similar lines.

The treatment of dyspnœa is equally important; and the air passages must be cleared of blood, if necessary by sucking it out. Artificial respiration should be performed if the patient has ceased to breathe. Preliminary tracheotomy is often necessary before undertaking the toilet of the wounds, and it may be advisable to leave a tube in the trachea for several days for fear of œdema of the larynx. The wounds must be made as aseptic as possible, and then completely closed by layers of catgut sutures inserted into the mucous membranes, cartilages, and muscles. By this means it is often possible to prevent cellulitis of the neck; and, even if a fistula forms, as is probable, it may heal later, or may be repaired by operation. If the tongue or cartilages of the larynx are divided, they should be sutured after cutting away loose tissues which are likely to become necrosed. The trachea and œsophagus should be treated in the same way, the mucous membranes being turned in before the sutures are tied.

The neck should be freely drained with tubes or gauze to prevent emphysema and septic collections, after which the skin may be partially closed.

*After-treatment.*—The patient should lie on his side, or propped up on pillows, with the head bent forward to relax the tension on the sutures. Normal saline must be injected into the rectum or into a vein if the hæmorrhage and shock have been severe. After suturing the œsophagus the patient may be fed entirely by the rectum for a few days, or by a tube passed beyond the wound at the time of the operation. Suppuration must be expected, and free exit given to the pus as soon as it forms. The patient, if a suicide, must of course be carefully watched. The mortality after cut throat is a high one on account of the shock from which the patient has suffered, and his low state of health at the time.

**Injuries to nerves** may occur with cut throat, but are more common with

deep wounds caused by stabbing and bullets ; or they may occur accidentally during an operation for the removal of glands or tumours of the neck. The nerves which are commonly injured are the spinal accessory, hypoglossal, superior or recurrent laryngeal, pneumogastric, sympathetic, or phrenic nerves, or part of the brachial plexus.

**Injury to the thoracic duct.**—This is extremely rare and is nearly always due to a surgical operation, such as removal of glands from the left side of the neck. The accident may occur on the other side when a right thoracic duct is present. In rare instances the duct has been divided by stabbing or bullets, or has been opened by the ulceration of a malignant growth. When there is an external wound the diagnosis is easy, since chylous fluid escapes from it, often in great quantity. If the fluid cannot escape on the surface it may find its way into the pleural cavity, and repeated tapping may be necessary. The symptoms are rarely serious, but the nutrition suffers when large quantities of chyle escape, and death may occur from inanition or repeated accumulations of lymph in the thorax.

*Treatment.*—When the injury occurs during an operation immediate suture should be attempted, and, this failing, the external wound should be firmly united and pressure applied over the wound. The latter method is sufficient in most cases to stop the discharge of fluid, and even when a swelling forms it may slowly disappear. Severe cases, when the main duct has been completely severed, are more serious, and require ligation or implantation into a vein.

**Contusions of the larynx** may be caused by blows or kicks, by garrotting, or by a cart-wheel having passed across the neck. The affected parts are usually painful, and there may be alteration or loss of voice. In some cases the skin will be bruised, or there may be localised swelling or ecchymosis. Hæmoptysis occurs if the mucosa of the larynx has been lacerated.

It is often difficult to determine whether the cartilages have been fractured or not. It is said that instant death has been caused by severe compression of the larynx from spasm of the glottis. A severe injury in this region must always receive the most careful consideration. Even when there is no external swelling or bruising, there is a danger of œdema of the larynx, and patients have been known to die in their sleep from it.

**Fracture or dislocation of the hyoid bone** is usually at the junction of the greater cornu and body, but may occur in any situation. It is associated with tenderness and pain on turning the head and attempting to move the tongue ; dysphagia ; hoarseness or aphonia ; a sense of suffocation on protruding the tongue ; hæmoptysis when there is laceration of the mucosa ; and later with extravasation or œdema above the glottis, with resulting cough and dyspnœa. Crepitus and abnormal mobility of the bone may be detected. In all suspected fractures of this region radioscopy is of the greatest importance.

The term *dislocation of the hyoid bone* is applied to a condition which is probably due to relaxation of the ligaments between the thyroid cartilage and hyoid, and is most commonly seen in tuberculous patients.

**Fracture of the cartilages of the larynx** may involve the thyroid or cricoid or both, that of the thyroid being the more common and of the cricoid the more serious. These fractures cause pain, which is increased on speaking or swallowing ; hæmorrhage and œdema of the mucous membranes, sometimes with emphysema ; expectoration of blood ; and, later, extensive swelling and offensive discharge into the mouth, or perichondritis and necrosis of a part of the cartilage. The danger to be apprehended is obstruction to respiration, which may become so considerable as to necessitate urgent laryngotomy or tracheotomy.

*Treatment of contusions and fractures.*—In mild cases treatment should be directed towards allaying the pain and preventing inflammation, by application of an ice-bag, or lead and opium lotion, over the larynx. If a fracture is detected, it is theoretically advisable to explore it so that it may be sutured or wired in its proper position; on the other hand, if the parts are in good position, careful strapping is often sufficient. In every case the possible necessity for tracheotomy must be considered, and, when performed, it is advisable to retain the tube for a few days until all the swelling has subsided.

**Laryngitis.**—Laryngitis, like rhinitis, may be acute or chronic, and in many cases is caused by a known infection. The majority of such infections are not dangerous to life, and cause remarkably little constitutional disturbance. The characteristic symptoms are hoarseness or loss of voice, cough and expectoration of mucus or muco-pus, and general local discomfort. In very septic cases serious complications may supervene. Although the disease may affect people who are in perfect health, it is more common in those who are unfit, or in people who are debilitated by renal or heart disease; after infectious fevers or as the result of exposure to wet or cold; or as a result of over-exertion of the voice, excessive smoking or drinking, inhalation of noxious dusts or vapours, or of injuries of any kind, or of the action of certain drugs, such as iodide of potassium. Children are very susceptible, and, once a weakness in the larynx is established, recurrent attacks become frequent, especially during the winter months.

The following acute forms are met with:—

**Catarrhal,** often recurrent and due to infection with the ordinary organisms of "colds," especially *micrococcus catarrhalis*, pneumococcus and influenza (Pfeifer's) bacillus. In this form spasms of the glottis are frequent, especially in children, associated with ringing cough and inspiratory dyspnœa—a condition which must not be confused with *laryngismus stridulus*, which is a pure spasm without catarrh.

**Septic.**—A severe form due to streptococcus, pneumococcus or staphylococcus. The pneumococcal form is especially dangerous, and may cause marked local or constitutional disturbance, in many instances being rapidly fatal. Under this heading are included cases with acute œdema of the larynx (œdematous laryngitis) and those which occur during the course of a specific fever, such as measles, scarlet fever, whooping-cough, and typhoid, in all of which tracheotomy may be necessary for the relief of the dyspnœa.

**Diphtheritic,** from infection with the Klebs-Loeffler bacillus. The disease is especially common in children, and usually starts in the pharynx and extends to the larynx. During the period 1902-1913, 54,852 cases of diphtheria were treated in the fever hospitals of London, and the mortality was 9·1 per cent. Out of this huge total only 7,548 (14 per cent.) had symptoms of laryngeal diphtheria, but the mortality was 17·1 per cent., or almost double that of non-laryngeal cases. Nearly half the laryngeal cases (3,243) required tracheotomy or intubation, and in these there was a mortality of 29·9 per cent. In this connexion it must be remembered that before the introduction of antitoxin, laryngitis was more common in diphtheria, tracheotomy was much more frequent, and 70 per cent. of the patients died. From the above figures it is obvious that laryngeal diphtheria must still be regarded as a dangerous disease. The symptoms of the complaint may be slight at first and difficult to distinguish from an ordinary catarrh. The temperature rises more slowly than in other forms of acute laryngitis, and rarely exceeds 103° F. In nearly all cases the diagnosis is easy because of the definite signs of the disease in the fauces. In severe cases the cough gradually becomes louder, acquiring

a ringing or brassy character, and is particularly troublesome at night. Paroxysms of coughing are usual, and as they increase in severity the inspiration becomes noisy and is accompanied by stridor. The voice is hoarse or reduced to a whisper or, in young children, totally suppressed. The alæ nasi are dilated, the extra muscles of respiration are called into action, and laryngeal excursion is seen. On examining the chest, recession is evident; and during inspiration the supraclavicular fossæ, the intercostal spaces, and the epigastrium are all indrawn. When the dyspnœa becomes urgent, restlessness is marked and indicates that an operation is required. In the worst cases the face is drawn and livid or extremely pale; respiration is deficient and the chest expansion feeble; the air entry into the lungs is imperfect, and the bases are dull to percussion. The action of the heart is feeble, rapid, or intermittent, and no nourishment can be swallowed. It is always difficult to determine how much of this collapse is due to toxic poisoning and how much to definite obstruction by swelling of the mucosa. In some cases membrane formation is very extensive, and practically fills the trachea and bronchi. It is of a greyish-white colour, and is produced by coagulation of fibrin with epithelium, leucocytes, and organisms in its meshes.

Fig. 313.—Œdema of the larynx. (St. Bartholomew's Hospital Museum.)

*Treatment.*—The importance of antitoxin has already been referred to. It should be given early and in large doses (from 8,000 to 20,000 units), irrespective of age, and repeated on the second day if necessary. The worse the disease the larger the dose that is required. In this way it is often possible to prevent serious laryngeal obstruction. On the other hand, there is abundant evidence to show that the best results are obtained by early operation (p. 757), especially in young children in whom the larynx is extremely small. It is unnecessary to describe in detail the general treatment of these cases; but attention must be drawn to the importance of a skilled nurse, of suitable feeding by a nasal tube if necessary, of stimulants, of the atmosphere of the room, and of steam or antiseptics in certain cases. Both the surgeon and the nurse must be careful that they are not infected by the patient.

**Chronic laryngitis: Simple.**—The causes are similar to those of acute laryngitis; and the symptoms are hoarseness or aphonia, soreness of the throat, and irritable or spasmodic cough with or without expectoration. The disease may be *catarrhal*, often secondary to nasal catarrh; *follicular* or granular (clergyman's sore throat); *atrophic*, secondary to atrophic rhinitis, with expectoration of offensive green crusts; *pachydermia laryngis*, a rare condition in which there is a chronic thickening of the epithelium and subepithelial tissues, chiefly of the vocal processes, and liable to be mistaken for tubercle, syphilis, and malignant growth, generally seen in men after middle life. The origin of this disease is uncertain, and there is no evidence that it is caused by either tubercle or syphilis. The treatment of pachydermia consists in vocal rest and local application of astringents;

operations are rarely advisable. Injections of salvarsan are sometimes very successful. Later training in voice production should be advised. *Singers' nodules* are supposed to result from faulty voice production, and are probably closely allied to pachydermia. The nodules appear as minute, ovoid swellings, of white or grey colour, and are usually situated at the free edge of each cord, at the level of the anterior and middle thirds. *Scleroma*, a disease in which there is a chronic fibrosis, chiefly affects the subglottic region and eventually leads to severe stenosis. This disease occurs in South-eastern Europe, never in Britain, and is due to an undiscovered organism. No cure is known.

**Chondritis and perichondritis.**—The cartilage or perichondrium may become infected by pyogenic organisms, especially in cases of tubercle, syphilis, and malignant disease; or occasionally after injury, or certain fevers such as typhoid and small-pox. Inflammation may also occur with any septic laryngitis, especially infections of pneumococcus and streptococcus. The disease may be acute or chronic; and causes pain, tenderness, œdema, and external thickening of the larynx which is often extensive. Suppuration is liable to occur, and the abscess may open into the larynx, pharynx, or œsophagus, or on the surface of the neck, leaving a fistula. In many instances the lumen of the larynx becomes so small that tracheotomy is necessary for the relief of dyspnœa. Free incisions may also be required.

FIG. 314.—Tuberculous laryngitis.

**Tuberculous laryngitis.**—Tubercle of the larynx is generally secondary to disease in the lung, and very rarely occurs as a primary affection. It is more than twice as common in males as in females, and chiefly affects people between the ages of twenty and forty, but very rarely children. The tubercle bacilli reach the larynx in most instances from the lung, rarely from the upper respiratory tract. They gain an entrance to the submucous tissue through the epithelium or ducts of the glands, and spread along the lymphatics and blood-vessels. Only in miliary tuberculosis of the larynx, a rare condition, does the infection come with the blood-stream. The symptoms are those of chronic laryngitis, namely, a weak and husky voice, very characteristic of this disease and sometimes leading to aphonia; an irritable throat, with cough and expectoration; and dysphagia, which may be of an extremely painful character when ulceration is present. In rare instances there may also be dyspnœa. The typical signs are swelling or infiltration of the sub-epithelial tissues most common in the arytenoid region or interarytenoid space, patchy redness or anæmia of the vocal cords and other parts, and a tendency to small superficial ulcers principally on the vocal cords. In severe forms, complicated by secondary infections, the ulceration may be extensive and lead to much destruction of tissues, or the swelling is more marked and affects the perichondrium (perichondritis); or so-called tuberculomata may be formed. The cervical glands are rarely affected. The disease may be difficult to diagnose from simple laryngitis, syphilis, and malignant growth. In every case of persistent laryngitis the chest and sputum should be critically examined.

*Treatment.*—The patient should carry out a strict sanatorium treatment and do everything that is possible to improve his general health. A suitable climate, free from dust and cold winds, is important. Complete rest of the larynx by silence maintained for months is still more necessary, and should be observed whenever possible. In suitable cases, and if given with discretion, tuberculin may also be helpful. For the relief of irritation, cough, or ulcerations antiseptic inhalations, sprays, or insufflations may be of use. Painting with lactic acid, 10 to 70 per cent., has been extensively tried; and for chronic infiltrations the electro-cautery may be employed. Operations such as curetting of ulcers and amputation of the epiglottis are not often advisable. Tracheotomy is rarely necessary, and should never be performed except for relief of dyspnœa. For the extreme pain on swallowing good results have been obtained by injecting alcohol into the internal laryngeal nerves.

**Lupus** also affects the larynx, and is a very chronic disease due to the tubercle bacillus and generally secondary to infection of the nasal or pharyngeal mucosa. Starting on the epiglottis, it forms a nodular thickening which may spread backwards to the posterior portions of the larynx and ultimately to the vocal cords. Ulceration is never severe, and there may be no symptoms except a slightly husky voice. The disease can generally be cured by the Copenhagen treatment (see p. 716); in rare instances amputation of the epiglottis may be advisable.

Fig. 315.—Syphilitic laryngitis.

**Syphilis.**—Congenital syphilis is rare, but the acquired disease is common. The secondary stages are characterised by catarrhal inflammation, superficial ulceration, and mucous patches. In the tertiary forms there may be hyperæmia, infiltrations, gummata, extensive ulcerations with destruction of tissues, or warty outgrowths, perichondritis or necrosis with a tendency to ultimate stenosis. The symptoms are a peculiarly rasping voice (rarely much aphonia) and a tendency to dyspnœa. Even when ulceration is present, there is not such marked cough, pain, or dysphagia as in a similar case of tubercle. The disease may be difficult to distinguish from malignant growth. Good results can generally be obtained by one or two injections of neo-salvarsan followed by mercury and iodides. Tracheotomy may be necessary, or intubation tubes when strictures have formed. In rare instances laryngo-fissure will be required to cure the stenosis.

**Tumours.**—Tumours of the larynx are more often innocent than malignant. It is very important to distinguish an innocent from a malignant tumour, because it is agreed that intra-laryngeal operations are preferable for the eradication of the former, while the latter are better treated by extra-laryngeal methods. The innocent forms include *papillomata* (39 per cent.), which occur as hard, warty excrescences, usually multiple, and growing on the vocal cords or front of the larynx. They frequently commence in childhood between the ages of four and seven, and show an inveterate tendency to persist throughout life. *Fibroma*, a small rounded tumour, sessile or pedunculated, attached to one vocal cord, comes next in frequency; other forms, such as *myxoma*, *cysts*, *angioma*, *adenoma*, *lipoma* and

*enchondroma*, are all extremely rare. The symptoms are hoarseness or aphonia, with occasional spasms of coughing. Pain and dysphagia are

FIG. 316.—Multiple papillomata.

FIG. 317.—Fibroma of vocal cord.

absent. With the larger tumours, and with multiple papillomata of children, dyspnœa, with a tendency to spasm, is a common and dangerous complication

*Treatment.*—Given suitable instruments, sufficient experience, and a tolerant patient, it is possible, with the help of cocain, to remove the majority of innocent tumours by intra-laryngeal operations. The growths can be avulsed with forceps, punched out by cutting instruments, or destroyed with the galvano-cautery or caustics, according to their size and situation. These manipulations have been rendered less difficult since the introduction of direct laryngoscopy. Multiple papillomata are the most difficult to treat because of their inveterate tendency to recur. The best results have been obtained by repeated removal through Killian's tubes, and by radium. The latter has been employed only recently for these cases, but has been shown to cause an atrophy of the warts when large doses (100 milligrammes) have been used. Better voice results also have been claimed with radium than with operative treatment. Trachco-

FIG. 318.—Intrinsic carcinoma of larynx. (St. Bartholomew's Hospital Museum.)

tomy, which was at one time supposed to effect a cure by giving rest to the larynx, is of no value, and should be reserved for the relief of dyspnœa alone. Thyrotomy is also useless, because it does not prevent a recurrence of the papillomata.

**Malignant growths.**—*Carcinoma* is common, and is generally of the squamous-celled variety. Sarcoma and endothelioma are rare.

Carcinomata occur mostly between the ages of forty and sixty, and attack males more than females. There are three varieties :—

1. *Intrinsic*, when the growth begins on the vocal cord or neighbourhood and lies entirely within the larynx. Such a tumour grows and ulcerates very slowly, and merely infiltrates the soft tissues of the larynx, stopping when it meets the cartilage. The cervical glands are never affected. In early stages there may be only one symptom, namely, persistent hoarseness. Later the vocal cord becomes fixed, and, if untreated, the growth slowly fills the larynx and causes dyspnœa. Intrinsic carcinoma may exist for two to four years before killing the patient. Treatment by thyrotomy (p. 755) gives excellent results.

Fig. 319.—Extrinsic carcinoma of larynx. (St. Bartholomew's Hospital Museum.)

2. *Extrinsic* growths start at the entrance to the larynx, near either the epiglottis or the cricoid, and are not truly laryngeal, but also involve the pharynx or œsophagus. Their course is always rapid, accompanied by early ulceration, excessive secretion of muco-pus, and frequently by blood-spitting, which may be copious. Pain, dyspnœa, dysphagia, and alteration of the voice supervene ; neighbouring tissues become involved, also the cervical glands ; the structures of the neck are displaced, cachexia follows, and the whole course of the disease is run in twelve to eighteen months. The results of operations are most unsatisfactory (see *Laryngectomy*, p. 756).

3. *Post-cricoid carcinoma* commences always on the back of the cricoid, near the upper end of the œsophagus. The disease is peculiar in that it is more common in women between the ages of thirty and forty than in men. In this connexion it must be remembered that carcinoma is extremely rare in the nose, pharynx, or mouth of women. The diagnosis of this condition is often very difficult unless an early œsophagoscopy is undertaken. The symptoms and progress of the disease simulate an extrinsic growth.

*Sarcoma*, which is very rare, is generally a spindle or a round-celled growth

of extrinsic origin. Such growths are very malignant, and rapidly invade the surrounding tissues and lymphatics, giving rise to symptoms like those of extrinsic carcinoma.

## Operations on the Larynx and Trachea.

**Surgical anatomy.**—Beginning at the chin is the raphé between the mylo-hyoid muscles; next comes the hyoid bone, and then the thyro-hyoid membrane, through which an incision is made in the operation of subhyoid pharyngotomy. Below this is the *pomum Adami*, with the notch in the thyroid cartilage, which is prominent in adults, especially in males, and can be felt in the fat neck of a child. An incision exactly in the middle line through the thyroid cartilage is known as thyrotomy. A little below the thyroid the cricoid can be felt. It is situated opposite the fifth or sixth cervical vertebra. Between the cricoid and the thyroid cartilage is the crico-thyroid membrane, which is quite superficial, and is covered only with the skin, the superficial and deep fascia, and the overlapping sterno-hyoid muscles. This is the spot where laryngotomy is performed. Below the cricoid cartilage are two or three rings of the trachea, and then the thyroid isthmus. There is usually a space between the cricoid cartilage and the isthmus of from $\frac{3}{8}$ to $\frac{3}{4}$ inch (1 to 2 cm.). Here the trachea is merely covered by the skin, the superficial and deep fascia, and the overlapping sterno-hyoid muscles on either side; and it is in this situation that tracheotomy is best performed. After the isthmus of the thyroid gland, which, in adults, is usually about $\frac{3}{8}$ inch wide, follow four or five rings of the trachea, and then the upper border of the sternum. Below the isthmus the trachea recedes from the surface, and, in addition to the skin and superficial and deep fascia, is covered by the sterno-thyroids as well as the sterno-hyoids, and by two layers of deep fascia between which is the large inferior thyroid plexus of veins. In front of the muscles the anastomotic communication between the anterior jugular veins also crosses the trachea. On the trachea itself are several small branches from the inferior thyroid arteries, and sometimes the thyroidea ima, an occasional branch coming off from the aorta. Rarely, too, the left innominate vein may be higher than usual and may cross the trachea above the level of the sternum. On either side of the trachea, low in the neck, are the carotid arteries. In exceptional cases tracheotomy has to be performed below the isthmus, but a review of these anatomical relations makes it evident how much greater is the risk and difficulty then attending the operation.

**Thyrotomy** (Laryngo-fissure).—*Indications :*—(1) Intrinsic malignant growths. (2) Innocent growths of large size. (3) Stenosis following syphilis trauma, acute exanthemata, or scleroma. (4) Foreign bodies (rarely necessary).

Every precaution must be taken to prevent blood from running into the trachea during the operation. This may be accomplished by preliminary tracheotomy, inserting an ordinary tracheotomy tube, and placing the patient in the Trendelenburg position. Some surgeons prefer to use a Hahn's cannula, allowing ten to fifteen minutes for the sponge to swell and block the trachea. A median incision is then made over the thyroid cartilage down to the tracheotomy wound. The larynx is opened exactly in the middle line by curved bone scissors, the inner blade being pushed through the crico-thyroid membrane. On retracting the alæ of the thyroid the larynx should be cocainised and a small sponge inserted into the upper part of the trachea above the cannula. The growth is freely excised, with the perichondrium lining the

cartilages. This must be done " without respect to the after-use of the voice or any other consideration except the complete removal of the disease " (Butlin). The alæ of the thyroid are allowed to fall together, and are kept accurately in position by sutures passed through the thyro-hyoid membrane and prelaryngeal muscles; occasionally a suture through the cartilages or external perichondrium is necessary, but it must never be allowed to pass into the larynx, because it gives rise to granulations and stenosis. The cavity of the larynx should never be plugged. The skin should be partially sutured, allowing for free drainage, and the tube removed. In rare instances it may be necessary to retain the cannula for a few days. The wound must be lightly dressed and the patient nursed on the side, with the face as low as possible. No dissection for removal of lymphatic glands is necessary. The dangers are broncho-pneumonia and, later on, stenosis.

**Hemi-laryngectomy** is suitable for extensive malignant disease which is strictly limited to one half of the larynx. In this operation half of the thyroid cartilage is taken away, the main consideration being the complete removal of the tumour, including the diseased tissues of the neck, the lateral wall of the pharynx, and the cervical glands of the same side.

**Total laryngectomy** is reserved for extensive cancers, extrinsic or post-cricoid. The trachea is first exposed and completely severed, its lower end being stitched into the lower part of the wound above the sternum. The lateral aspect of the larynx is freely separated, the superior laryngeal arteries are ligatured, and the attachments of the inferior constrictor muscles of the pharynx are divided. The larynx is then hooked forwards and dissected from the œsophagus from below. Finally, the œsophagus and thyro-hyoid membrane are cut across. In order to restore the cavity of the pharynx the upper end of the œsophagus is carefully sutured to the region of the hyoid bone, and the infrahyoid muscles are also brought together to cover the wound. A tube must be passed through the mouth into the œsophagus and retained for purposes of feeding. In Gluck's operation the dissection is done from above downwards after first dividing the thyro-hyoid membrane, the trachea being severed as a final stage of the operation.

**Laryngotomy** (Infrathyroid).—The larynx is opened through the crico-thyroid membrane. The operation is an easy one in adults, but in children the crico-thyroid space is so small that it is almost impossible to introduce a tube without division of the cricoid cartilage. The tube when introduced lies in the subglottic space, well below the vocal cords. *Indications :*—(1) Sudden laryngeal obstruction due to impaction of food or foreign body. (2) Sudden œdema after trauma or inflammation, when the equipment for tracheotomy is not obtainable. (3) As a preliminary to major operations upon the upper air passages, to prevent blood from passing down into the trachea. Preliminary laryngotomy is valuable before removal of tumours of the tongue, floor of the mouth, jaws, palate, tonsil, and nasopharynx. A transverse incision, 1 inch in length, should be made directly over the crico-thyroid interval. By picking up a vertical fold of skin and transfixing it the cut can be made quickly and should not injure the anterior jugular veins. The operation can be completed in ten to fifteen seconds by stabbing a sharp-pointed dilator through the crico-thyroid membrane exactly in the middle line, between the infrahyoid muscles, and widely dilating it so as to tear open the membrane. On withdrawing the dilator a laryngotomy cannula can be introduced with ease. *Complications :*—Hæmorrhage rarely occurs with this operation, but is more common when the membrane is divided with a knife; difficulty in introducing the tube may result when too small an

opening has been made; later on there may be surgical emphysema, but this rarely occurs unless the wound has been sutured; bronchitis or septic pneumonia may supervene, but probably are never due to the operation.

**Intubation** is extensively used for the treatment of diphtheria. Intubation is extremely valuable also in stenosis of the larynx, but rarely for other forms of laryngitis. The advantages claimed for it are: no anæsthetic required; consent of friends is easily obtained; no cutting, great rapidity, no wound to heal; tube worn more easily than a tracheotomy cannula; breathing through natural passages, so that warmth and moisture are added to the air. The practical disadvantages are: it is quite unsuitable except at special hospitals, since great dexterity and constant practice are necessary; accidents are frequent; failure to introduce the tube is common; the tube may be blocked or coughed up, and does not provide good drainage; swallowing is difficult; complications such as broncho-pneumonia, ulceration, and cicatrisation are common; after-treatment is difficult, and constant watching is required; secondary tracheotomy is often necessary and has a high mortality; retained tube may occur. In considering the above points the surgeon must advise what he considers the better operation, and this must depend largely upon his experience. Intubation ought not to be tried indiscriminately by those who have no knowledge of the practical difficulties.

The operation is performed with the patient in the upright position. In children a blanket should be wrapped round the arms, body, and legs to control the struggling. Two assistants are necessary, one to hold the child, the other to steady the head and manipulate the gag. A tube, suitable to the age of the child, is mounted on an introducer and taken in the right hand. The mouth being opened to the fullest extent, the surgeon passes his left forefinger over the tongue and epiglottis until the cricoid is felt. The finger is then drawn forwards, and acts as a guide for the tube passed by the right hand. In this way the tube is passed through the larynx until its upper flange rests firmly on the ventricular bands, where it is held until the introducer has been removed. If three attempts at intubation have failed it is better to desist. It is important to remember that tracheotomy is required in nearly a third of the cases that are intubated for diphtheria.

**Tracheotomy.**—Tracheotomy, even under favourable circumstances, is attended by many *difficulties*. It is important to be well prepared with good equipment and light, and three capable assistants are preferred. The operation must never be commenced until the proper position is obtained, with the head well extended and exactly in the middle line. Novocain anæsthesia is safer than chloroform.

*High tracheotomy* (section of the trachea above the isthmus) is preferred, because this part of the trachea is more superficial, less movable, and easier to find. An incision 1½ inch in length is made from the cricoid cartilage downwards, and exactly in the middle line. After dividing the skin, the incision is continued through the septum between the sterno-hyoid muscles. Bleeding vessels are seized. The isthmus of the thyroid gland should now be seen, but the landmark that is required is the cricoid. When this is located the pretracheal fascia and isthmus can be dragged downwards by a blunt hook, and the upper two or three rings of the trachea are then exposed and incised with an upward cut. On pricking the trachea there is a sudden rush of air out of the lungs, and a dilator should be introduced. The patient's head is at once drawn over the end of the table so that blood cannot be sucked into the lungs. The wound being widely dilated, the patient (after a momentary pause) should begin to cough, thus expelling the membrane and pro-

moting better expansion of the lungs. The tube should not be introduced until regular breathing has been restored. In rare instances it may be necessary to insert a rubber tube with a syringe attached and suck out the discharge. The fact that a number of surgeons have lost their lives from sucking through the catheter in the attempt to save the child is sufficient condemnation of the practice. Although the operation can be done with great rapidity, a deliberate operation is much to be preferred by those who have not had considerable experience.

*Low tracheotomy* (section of trachea below the isthmus) is more difficult, because the trachea is deeper and more movable and has more complicated relations to the important vessels at the root of the neck. No attempt should be made to perform this operation rapidly, or to open the trachea before its rings have been thoroughly exposed by dragging the isthmus upwards. There is a tendency for the tube to slip out after this operation; therefore a long cannula should be used.

The accidents that occur during tracheotomy are usually the result of inexperience. They include hæmorrhage, failure to breathe, to which must sometimes be added failure to find the trachea, or wounding of the œsophagus. The after-treatment is a matter of the greatest importance (see p. 750), and it is the surgeon's duty to prevent a recurrence of the obstruction. As soon as the secretion becomes small in amount an attempt should be made to remove the tube, the usual period varying from five to fifteen days. The complications arising after tracheotomy are wound infection, sepsis, ulceration or granulations in the trachea, stenosis after crico-tracheotomy or long wearing of the cannula, paralysis of the vocal cords, broncho-pneumonia, emphysema, secondary hæmorrhage (common after low tracheotomy), and cardiac paralysis.

As stated on p. 749, the mortality of tracheotomy for diphtheria is 29·9 per cent. It must be remembered, however, that although nearly one-third of these cases die, it is the disease and not the operation which is responsible for most of the deaths.

## Surgery of the Œsophagus.

**Anatomy of the œsophagus.**—The œsophagus in an adult is 9 inches long, and lies in front of the bodies of the vertebræ, reaching from the fifth cervical above to the tenth dorsal below. The important anterior relations from above downwards are the trachea, left bronchus, ascending aorta, pericardium, and left vagus. Posteriorly, in addition to the vertebræ, lie the thoracic duct, descending aorta, and right vagus. Laterally the œsophagus is covered by the pleura. In men the distance from the teeth to the cricoid is roughly 6 inches, to the bifurcation of the trachea 10½ inches, and to the cardiac orifice 16 inches.

**Examination of the œsophagus.**—Owing to the deep position of the œsophagus, even of its cervical portion, *inspection and palpation* are rarely of much practical value. *Auscultation*, however, is more important. When water is passed through the normal œsophagus a "squirting murmur" can be heard, with the stethoscope placed over the cardiac orifice, three to five seconds after the act of swallowing. With strictures and spasmodic con tractions the murmur may not be obvious until eight to fifteen seconds later. Even when suffering from such a complaint swallowing may appear to be easy, but the fluid is delayed in the distended œsophagus above the stricture, and the squirting sound may not be heard until the patient strains.

*Radiography* also is of the greatest possible value. The chest should be

examined with X-rays to ascertain if there is a shadow in the mediastinum suggestive of growth, and to eliminate the possibility of diseases of other organs, such as aneurysm of the aorta or tuberculous infection of the lungs. To determine that the œsophagus is healthy a bismuth meal should be swallowed and its passage through the gullet carefully observed. Normally, the bismuth will be seen to shoot through into the stomach; but its passage is considerably delayed when the œsophagus is diseased. By taking an X-ray plate it is generally possible to determine the situation and length of a stricture, and thus to obtain a record of the case.

*Examination with sounds and bougies.*—The equipment which is required consists of solid flexible bougies with blunt or olive-headed tips, hollow catheters and stomach tubes, stiff whalebone or catgut sounds, according to the fancy of the surgeon. Such instruments may be passed blindly, as is commonly performed in the routine examination of out-patients, or by sight through an œsophagoscope; but great care must be observed, since, if force is used, the œsophagus may be injured so severely that death results. The contra-indications are acute inflammation of the œsophagus, aneurysm of the aorta, cirrhosis of the liver, uncompensated heart disease, phthisis, and emphysema. It is therefore important to examine a patient thoroughly before passing a sound.

The technique of the method is as follows:—The patient should sit upright in a chair facing the surgeon, and his pharynx, tongue, and larynx should be painted with cocain or novocain (10 per cent.). It is best to pass a medium-sized bougie (No. 20) first. To overcome the difficulty of passing the cricoid the patient should be instructed to lean well forward and extend the head as much as possible, also to open the mouth widely and breathe quietly. The surgeon hooks his left forefinger over the base of the patient's tongue, and, pulling it forwards, passes a well-oiled sound with his right hand. On reaching the cricoid the patient should be told to swallow in order to facilitate the passage of the sound into the œsophagus. He should then lean the head further forwards, and continue to breathe while the sound is pushed along the gullet. Should pain be experienced, it may be due to inflammation, ulceration, or tumour—conditions not to be confused with neurosis. With a normal œsophagus a sound will pass into the stomach without difficulty; on the other hand, when a stricture is present, the obstruction is generally obvious owing to the sudden stoppage of the sound. Gentle pressure may be maintained for a time to determine whether the obstruction is caused by spasm or disease. The former may suddenly give way; but with a stricture a bougie is gripped, or a roughness is felt, and on trying to withdraw the sound the gripping may become more obvious. Before removing the bougie its relation to the upper teeth should be noted, so that after removal the distance of the stricture from the teeth can be measured. On taking out the sound it should be examined for blood, mucus, or food, it being remembered that a normal œsophagus contains no food-remains or blood. Smaller sounds may then be tried to discover if the stricture is permeable, and to gain an idea of its size and length. If nothing can be passed with ease, it is advisable to abandon the operation in favour of œsophagoscopy.

*Direct inspection, or œsophagoscopy*, is the most scientific method of examining the gullet, and is useful for the diagnosis and treatment of foreign bodies, malformations, strictures, and growths. The apparatus required and the technique are similar to those described under *Bronchoscopy* (see p. 742).

With *endoscopy* the following points can be observed:—*The character of the mucous membrane:* the normal mucosa is of a delicate pink colour and

uniformly shiny in appearance. *The lumen :* this varies in different positions ; the cervical portion is collapsed and appears as a transverse slit, but the thoracic part is widely open and has a more circular outline ; constrictions can be seen at the level of the cricoid cartilage and at the diaphragm ; slight bulgings are also caused by the aorta and the left bronchus. *Movements :* three different movements may be observed—namely, respiratory, the most important because they are always present apart from disease ; pulsating, due to beating of the aorta or heart ; and peristaltic, caused by entrance of the tube into the œsophagus.

**Rupture of the œsophagus** may be due to injury from outside owing to a wound of the neck (see p. 746), or from within as the result of foreign bodies or sword-swallowing ; it may also be caused by instruments such as bougies, coin-catchers, or œsophagoscopes ; or by disease, for instance prevertebral abscess, empyema, caseating bronchial glands, aneurysm of the aorta, or cancer in the neck or mediastinum ; rarely by excessive vomiting after an anæsthetic or emetic, or accidentally in a patient suffering from chronic alcoholism. The last generally occurs in males, and the rupture is commonly longitudinal and close to the cardiac orifice. The symptoms vary according to the size and situation of the rupture, and are very severe if all the coats are torn. There may be pain, retching, dyspnœa, emphysema of the neck, or collapse ; and death may supervene in twenty-four hours. With a perforation which is caused by disease the symptoms are not so definite and the condition may be difficult to diagnose. When the opening communicates with the air passages, food may be coughed up after swallowing ; and, if a tube is passed into the œsophagus, air will be heard passing in and out of the perforation with respiration. The treatment of these conditions is difficult ; but the question of rectal feeding, gastrostomy, and, in rare instances, immediate suture of the wound should be considered.

**Removal of foreign bodies from the œsophagus** (see p. 745).

**Hæmorrhage** from the œsophagus is not uncommon, and may be caused by a leaking aneurysm, varicose veins at the cardiac orifice (most common in connexion with cirrhosis of the liver), malignant ulcer, or any other condition which leads to a rupture of the lining membrane. The condition can be diagnosed from hæmatemesis by the alkalinity of the blood, or by discovering the seat of the bleeding by œsophagoscopy.

*Treatment* should consist in absolute rest in bed, rectal feeding, and sipping of ice or adrenalin. Plugging the œsophagus with gauze introduced through an œsophagoscope has been attempted, but in severe hæmorrhage the prognosis is serious.

**Inflammation of the œsophagus** may be acute or chronic. The following acute forms are met with :—*Traumatic*, caused by swallowing boiling water, corrosive poisons, or foreign bodies ; *septic*, in people who have indulged in excess of alcohol or smoking ; or in connexion with certain infectious fevers, especially typhoid, scarlet fever, and diphtheria. Chronic œsophagitis may be due to the same causes, or to syphilis (in which case it is always the upper end of the gullet that is affected), or in rare instances to tubercle. The symptoms are fever, pain, dysphagia, and regurgitation of offensive mucus or pus.

*Treatment* must depend upon the cause. In cases of poisoning a tube must be passed at once, and the stomach and œsophagus washed out thoroughly—a safer proceeding than giving an emetic. Acids must be neutralised with soap solution, and alkalis with vinegar and water. Later, the patient must be fed per rectum, or given sips of milk or oil by mouth ; and the pain must

be alleviated with morphia. Bougies should not be passed for four to six weeks owing to the danger of rupturing the gullet. In most instances troublesome strictures result, and gastrostomy may be necessary at any time for purposes of feeding. Simple forms of inflammation require mild antiseptics such as boro-chloretone.

**Ulcers of the œsophagus.**—Many varieties of ulcer occur—namely, those due to carcinoma, perforating tumours of the neck or mediastinum, foreign bodies, leaking aneurysm, syphilis, tubercle, or actinomycosis. Peptic ulcers are not so common. Œsophagoscopy is of value in the diagnosis of these conditions.

**Stenosis of the œsophagus** may be due to compression from without (not to be confused with paralysis), to spasm of the muscular coats, or to stricture. Three forms of stricture are met with—namely, congenital, fibrous, and malignant.

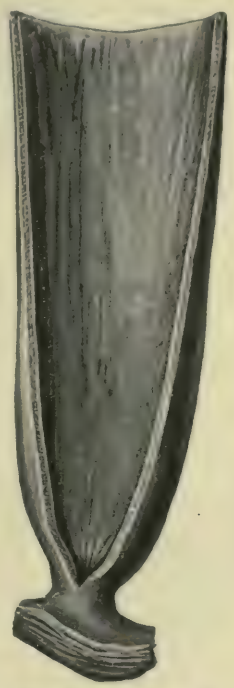


Fig. 320.—Simple stricture and dilatation of the œsophagus (cardiac end). (St. Bartholomew's Hospital Museum.)

**Compression from without** may be caused by a thyroid tumour (generally malignant), cancer of the larynx or enlarged cervical glands; by aneurysm of the aorta, mediastinal tumour, pleural or pericardial effusion. But in an obscure case cancer is the most probable cause of the obstruction.

**Paralysis** may be functional or organic. The former is common in hysterical patients; and causes dysphagia of varying degree, which often persists for long periods without causing loss of weight. The condition is easy to diagnose from other forms of obstruction, such as cancer, since it is generally met with in young women in whom other signs of hysteria are present. The patient should be reassured and treated with medical remedies or bougies. If necessary an anæsthetic may be given to dilate the œsophagus with sounds. Such treatment will often relieve the dysphagia, and give the patient the impression that she is cured. Organic paralysis is much less common, but may be met with as a complication of some central lesion of the medulla or of such diseases as locomotor ataxia and general paralysis of the insane.

**Spasmodic contraction of the œsophagus.**—Slight forms of spasm or cramp on swallowing are well known, and occur in children, nervous women, drinkers and smokers. During a hurried meal it is not unusual to experience a sensation of pain while a piece of food is slowly passing along the gullet, and great is the relief when the cramp disappears. Similar conditions occur with certain diseases such as tetanus, rabies, hysteria, chorea, and strychnine poisoning. There remains the more important variety known as *œsophagismus* or *cardiospasm*, in which a part of the gullet may remain contracted for some considerable time. The onset of this condition may be sudden, and may result from swallowing a small fragment of food. In one case seen by the author, a man stated that while swallowing soup containing small bits of carrot he felt one of the pieces stop at the lower end of the gullet, after which he was unable to swallow even water for the next ten days. When asked to drink he appeared to swallow with ease, but affirmed that the water had

not passed into his stomach. An X-ray examination with bismuth showed that the fluid had collected above the stricture, causing a ballooning of the walls of the gullet. A bougie was passed and an obstruction was found at the cardiac orifice. After steady pressure had been maintained for about fifteen seconds the spasm suddenly yielded, and the bougie passed with ease into the stomach. At once the patient stated that he was cured, and was able to swallow normally again. Cardiospasm often persists for years, during which time there may be periods of recovery. In such cases the whole length of the œsophagus may become dilated by food retained above the stricture. The etiology of this condition is uncertain. It has been said that it predisposes to cancer. The diagnosis can be made with X-rays and œsophagoscopy.

*Treatment* should consist in dilatation of the stricture with sounds, careful dieting, and other forms of medical treatment; in rare instances gastrostomy may be required; occasionally the spasm disappears and normal swallowing is restored as soon as the stomach has been opened.

**Congenital stricture or malformation** is very rare, and is generally fatal in the first week of life. The œsophagus may be imperforate, or occluded by a membrane; in other cases its upper end leads into the trachea or bronchus. The exact condition can be determined only by œsophagoscopy.

The *treatment* is gastrostomy, but it is unlikely to be successful in saving the patient's life.

**Fibrous stricture** may result from any severe injury or inflammation, and is due to contraction of fibrous tissue. It is very much rarer than malignant stenosis. When of long standing it is said to predispose to cancer. The stricture, though sometimes annular, is more often diffuse and involves the greater part of the gullet. Above the stenosis the œsophagus becomes dilated, the muscular coat hypertrophied, and the mucosa thickened and arranged in folds. The diagnosis is usually easy from the history; but a doubtful case should be examined with X-rays and sounds, and by œsophagoscopy.

The *treatment* of this condition requires great ingenuity and patience. In the first place dysphagia must be relieved, if necessary, by performance of gastrostomy. An attempt must then be made to dilate the stricture. Many different methods have been suggested, of which the following are the chief varieties:—

1. *Intermittent dilatation* by bougies passed through an œsophagoscope, or along a guide which has been previously introduced through the stricture. If the passage is difficult to find, the patient should try to swallow a piece of silk with shot attached to it, and this should be retained as a guide.

2. *Continuous dilatation* by intubation with long or short tube, the treatment being continued for many months (see *Intubation in Malignant Stricture*, p. 764). Such treatment often gives excellent results.

3. *Operative measures.*—The following methods are available:—

(*a*) To divide the stricture by internal œsophagotomy performed through the mouth, the cut being made in the posterior wall of the œsophagus. Many instruments have been devised, and are similar to those used for internal urethrotomy. Such an operation is not free from danger, but is much less severe than Abbé's method, in which, after preliminary gastrostomy and œsophagotomy, a string is passed through the œsophagus from the wound in the stomach to the incision in the neck and used to saw through the stricture.

(*b*) To perform gastrostomy and dilate the stricture from below. A good method is that devised by Ochsner, who passes a thread through the stricture from the mouth, bringing it out of the opening in the stomach. To the lower end of the string a rubber tube is attached and drawn upwards

through the stricture. This proceeding is possible even when the lumen is very narrow, for it is obvious that the greater the traction the thinner the tube becomes. When once the tube has been inserted there is a tendency for it to return to its original size, and thus the stricture is dilated.

Since the introduction of œsophagoscopy such severe operations are rarely necessary. Although endoscopic intubation may entail many months of

Fig. 321.—Skiagram, taken after bismuth meal, showing simple annular strictureof the œsophaguswith dilatation above and below it (instantaneous photograph). (Finzi.)

treatment, it is usually successful in relieving the stenosis, and external œsophagotomy is no longer necessary.

**Tumours.**—Innocent tumours of the œsophagus are very rare, but the following forms are met with—namely, myoma, adenoma, lipoma, fibroma, and cysts. In most instances the presence of the tumour is not suspected until it has reached a moderate size or become pedunculated or polypoid. The diagnosis of these cases can be made by œsophagoscopy.

**Sarcoma.**—Primary sarcoma is also very rare, but cases have been reported in the upper part of the œsophagus and opposite the bifurcation of the trachea.

**Carcinoma** is terribly common, and is met with more frequently than any other surgical disease of the œsophagus. It nearly always occurs in men over fifty, and is of the squamous-celled variety (epithelioma). At the cardiac end it may be glandular or colloid in type owing to extension from the stomach. The common situations are opposite the cricoid cartilage, at the bifurcation of the trachea, and at the cardiac orifice of the stomach. Epithelioma may commence as a cauliflower excrescence from one side of the gullet, but can rarely be seen in this stage; it is more commonly found as a nodular infiltration involving the whole of the coats of the œsophagus and causing definite obstruction of its lumen. The growth rapidly ulcerates and invades the surrounding tissues. It extends to the glands, the mediastinum, pleura, lungs, or pericardium; it may involve the vagus nerves or perforate the aorta, the trachea, or left bronchus; or, when in the cervical region, may form an external fistula in the neck. The prognosis is most unfavourable, and death occurs in most instances within a year, from inanition, exhaustion, and pain, or from involvement of the air passages (septic bronchopneumonia), of important vessels, or from mediastinitis; or the patient may succumb to phthisis.

The *symptoms* and *signs* are increasing difficulty of swallowing, first of solids, then of liquids, and finally complete dysphagia; regurgitation of food, most troublesome when the disease is in the upper part of the œsophagus; rapid loss of weight, amounting to from one to three stones in different cases; pain, which may be deep-seated or darting in character; paralysis of one or both recurrent laryngeal nerves, according to the situation of the growth, or paralysis of the sympathetic, resulting in contracted pupil; constant spitting of saliva and mucus, often in great quantity; hæmorrhage from the œsophagus or air passages, usually small in amount; enlargement of the glands above the clavicle. Unfortunately, when such symptoms are present, there is rarely any doubt as to the diagnosis, and the following routine examination must always be carried out:—Examination of the chest with X-rays and with the stethoscope; with the former it is possible to exclude aneurysm of the aorta and to determine the exact situation, size, and length of the stricture. Examination of the larynx to note if there is abductor paralysis. Œsophagoscopy and passage of bougies. Removal of a portion of the growth for microscopical examination, either through a tube or with Bruening's curette; the latter is a simple instrument which in many cases will remove enough tissue for the purpose of a section and is very useful when the requirements for endoscopy are not available.

*Treatment.*—In the majority of cases palliative treatment alone is possible. The patient should be given a diet which can be swallowed with ease, such as milk, concentrated soups, and soft semisolids. Medicines are of little value, but potassium iodide may be given internally, or atropin to reduce the saliva and mucus. Local antiseptics are often important, and may be used in the form of lozenges or in solution; or cachets of boro-chloretone (gr. iii.) may be swallowed occasionally. Lavage of the œsophagus is indicated if the secretion is constantly foul. The main principle of treatment, however, is to prevent the lumen from contracting so that the patient cannot swallow his food and saliva, and this can be effected in various ways:—By *bougies.*—This method is undoubtedly dangerous unless it is carried out with œsophagoscopy, and at best gives only temporary relief. *Intubation.*—Various forms

are employed, of which the two chief varieties are: (*a*) Short tube, such as Symonds's, which is passed through the stricture by means of a suitable introducer and left *in situ* for from one to three months. To prevent the

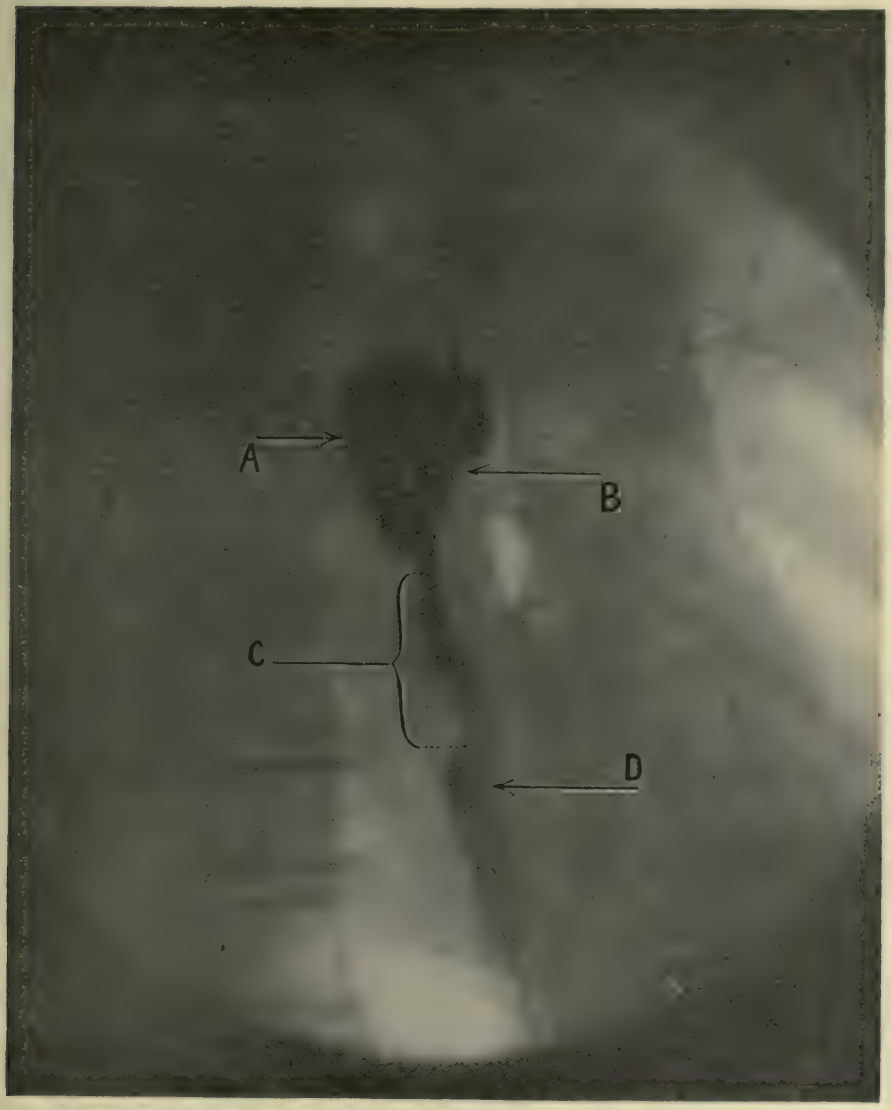



FIG. 322.—Skiagram, taken after bismuth meal, showing malignant stricture. (Hill.) A, Dilatation above stricture. B, Impression caused by growth. C, Stricture. D, Normal gullet.

tube from passing into the stomach a strong silk is attached to it and tied to a tooth or to strapping on the cheek. Such a tube may give great relief, especially when the cancer is in the middle of the œsophagus. On the other hand, it may not be well tolerated because of the pain and irritation which are often produced, especially with disease at the upper or lower end of the gullet (*b*) Long tube, such as William Hill's; the tube is easy to pass and

can be attached to the teeth by a dental plate; it can be used in all cases, whatever the position of the growth, and is the best form of intubation that so far has been devised. *Radium.*—Hill and Finzi have treated over thirty cases, using from 100 to 200 milligrammes of screened radium; and Hill says, "The method is the most recent and probably the most valuable palliative measure which has been employed in cancer of the gullet." As a result of this treatment the stenosis may be relieved for a time, ulceration may heal, and "there may be temporary disappearance of all naked-eye objective evidence of disease" (Hill). *Gastrostomy* must also be considered. This operation has many and grave disadvantages. In the first place, it is doubtful whether it ever prolongs life; secondly, it is often followed by pneumonia, especially if a general anæsthetic has been employed; again, if the operation is successful, the after-condition of the patient is terribly sad, and he can never return to his work; lastly, better results can sometimes be obtained by simpler methods. The author is of opinion, therefore, that gastrostomy should be reserved for cases with impermeable strictures, and that it should be performed before the patient has been weakened by starvation. There remain the exceptional cases in which a radical removal of the disease should be attempted. These are usually cancers in the region of the cricoid, and operations such as œsophagectomy, with or without laryngectomy, may be temporarily successful.

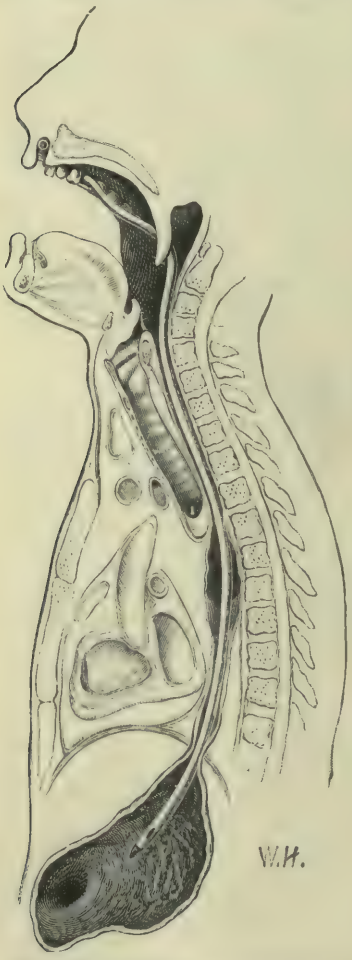



FIG. 323.—Intubation of stricture with Hill's tube.

**Dilatations and pouches.** — Four varieties have been described, namely:—(1) *Congenital*, which are rare and generally situated in the lower part of the gullet. (2) *Stricture dilatations*, in which the œsophagus has become dilated owing to the pressure of fluid or food collecting above a stricture, commonly met with in cases of carcinoma, œsophagismus, and cardiospasm. (3) *Traction diverticula*, caused by old-standing inflammation of tuberculous glands, thickened pleura, or, more rarely, by cervical caries, the wall of the œsophagus becoming first adherent and later pulled out by contraction of fibrous tissue. Such pouches are usually small and are discovered post mortem. (4) *Pressure pouches*, which are the most important, many cases having been described. The opening of a diverticulum of this character is always situated at the same place, namely, in the lowest part of the pharynx and posterior to the cricoid cartilage, where there is a weak spot between the lowest fibres (Fig. 324, B) and the oblique band (Fig. 324, C) of the inferior constrictor muscle of the

pharynx. The sacculation is supposed to be caused by the strain thrown upon this part by the effort of swallowing food. As the bulging increases, the sac gravitates downwards, generally on the left side of the œsophagus and behind it, and this close relation to the gullet has led to the term "*œsophageal pouch.*" It is, however, more correctly described as *pharyngeal.*

A pharyngeal pouch is more common in the adult male than in the female; it consists of mucous membrane and submucous tissues only; it causes a

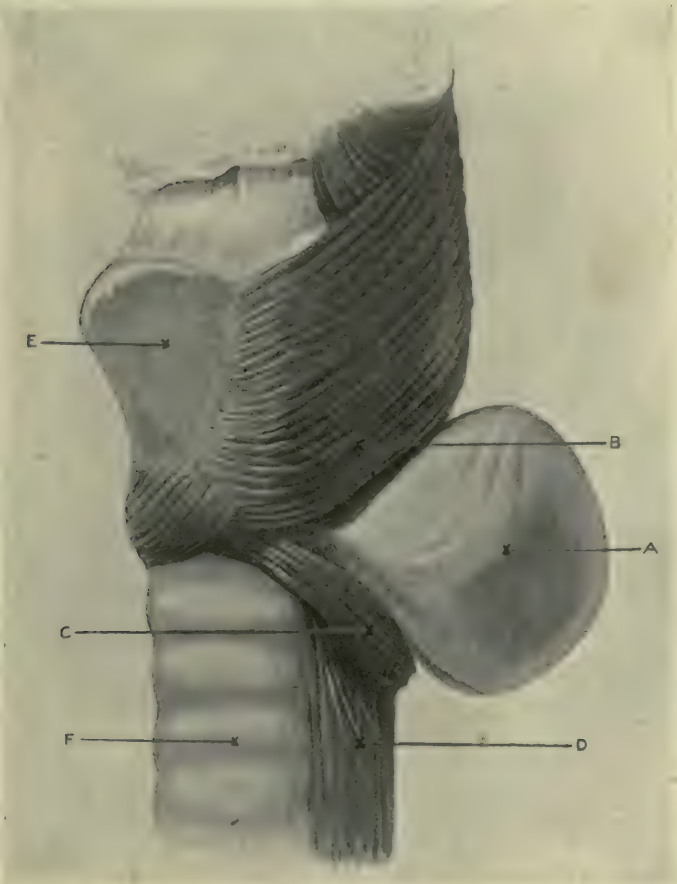



FIG. 324.—Pharyngeal pouch. (After Keith.) A, Pouch. B, Inferior constrictor (propelling part). C, Inferior constrictor (sphincteric part). D, Œsophagus. E, Thyroid cartilage. F, Trachea.

swelling of the left sterno-mastoid muscle in the lower part of the neck; in most instances the pouch becomes more obvious after swallowing, and can be emptied by pressure from outside the neck: when the opening into the pharynx is constricted the sac may be filled with air. The symptoms are dysphagia, varying according to the size of the pouch and sometimes sufficiently severe to cause inanition; gurgling noises on swallowing; regurgitation of mucus or food containing no gastric secretion and usually quite unchanged; rarely the sac becomes infected and the breath fœtid from decomposition of food; ulceration leading to cellulitis has also been reported.

Untreated, the disease may be fatal from starvation or septic pneumonia. The diagnosis is usually easy and can be made by observing the symptoms and signs, by passage of a bougie, by X-ray photography (Fig. 325), and still better by œsophagoscopy. In many instances the œsophagoscope passes into the pouch, and it is difficult to see the opening of the gullet.

*Treatment.*—This depends on the size of the pouch. When small, relief

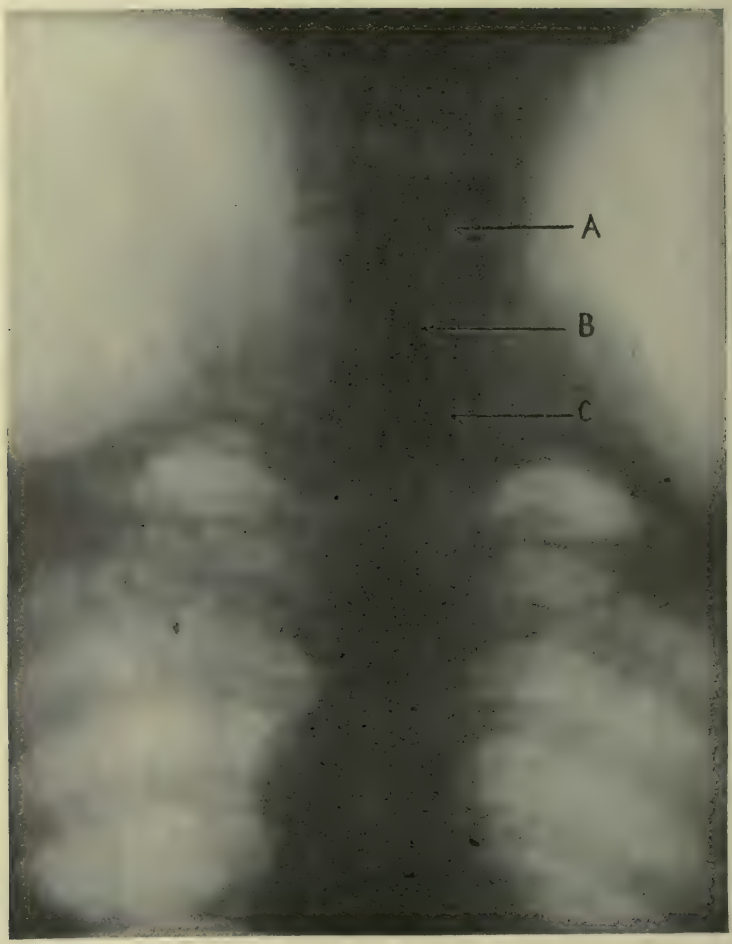



Fig. 325.—Skiagram, taken after bismuth meal, showing pharyngeal pouch (Finzi.) A, Dilated pharynx. B. Neck of pouch. C, Pouch.

can often be afforded by repeated passage of large bougies to dilate the opening of the œsophagus. For larger diverticula an external operation is generally advisable and is the only means of curing the symptoms. The sac is exposed as in cervical œsophagotomy and can be treated in various ways. If thin it can be invaginated into the œsophagus, and the muscles can be brought together over its base by transverse sutures. For medium-sized pouches Hill's operation (œsophagopexy) is a safe and valuable method. The sac having been freed is drawn upwards and fixed by four or more sutures to the lateral aspect of the pharynx with its apex upwards and its neck below,

in which position food is unable to enter the pouch. For fear of leaking, the sutures must not penetrate the walls of the sac or of the pharynx. The space formerly occupied by the pouch should be obliterated by suturing the fascia behind the sterno-mastoid to the side of the thyroid gland and trachea, thus preventing the sac from falling back to its original position. The external wound can be closed. Large pouches can be removed by the two-stage operation of the Mayos. At the first sitting the sac is freed and sutured to the skin as in the operation of colostomy. Ten days later, when the base is firmly adherent, its projecting part can be cut away and the skin turned in and united by a few sutures. The sac can also be excised completely. The pedicle is divided and the mucous membranes and muscles are sutured in different layers. Such an operation is by no means free from danger, and to prevent cellulitis free drainage of the wound is important. Preliminary gastrostomy has been advised, but it is an unnecessary complication. The after-treatment is similar to that of œsophagotomy, and includes rectal feeding for at least four days.

## Operations upon the Œsophagus.

**Cervical œsophagotomy.**—This operation is performed for the removal of a large or sharp-pointed foreign body which has caused severe inflammation or swelling so that extraction by œsophagoscopy is impossible or dangerous (see p. 746). It is also undertaken occasionally in cases of injury or rupture of the gullet (see p. 760), for the treatment of fibrous stricture, or for the removal of a large innocent tumour which cannot be treated by endoscopic methods. An incision is made along the anterior border of the left sterno-mastoid muscle from a point opposite the superior border of the thyroid cartilage to the sterno-clavicular articulation. After dividing the deep cervical fascia and the omo-hyoid muscle, the thyroid gland and trachea are pulled inwards and the carotid vessels outwards, the œsophagus being thus exposed. If necessary a sound can be introduced into the gullet in order to make it more definite. Before an opening is made the recurrent laryngeal nerve and the inferior thyroid artery must be isolated. The incision into the œsophagus should be longitudinal. After removal of a foreign body the wound should not be sutured unless the tissues are found to be healthy. In all cases free drainage of the wound in the neck is essential in order to prevent cellulitis. The after-treatment is similar to that required with operations on the pharynx or larynx. The operation has a high mortality.

**Cervical œsophagectomy.**—Resection of a portion of the œsophagus is generally undertaken for carcinoma affecting the upper part of the gullet, especially in conjunction with total laryngectomy or lateral pharyngotomy. Extensive resection for malignant disease is very difficult, and when more than 4 cm. has been removed it is impossible to unite the two ends of the gullet. Under these conditions the upper end must be sutured into the wound in the neck so as to produce a fistula, and the lower end closed and dropped into the thorax. The patient is fed through a gastrostomy wound. The operation is of little practical value because of its high mortality and the fact that it is impossible to prevent a rapid recurrence of the disease.

# Section XVI.

## SURGERY OF THE CHEST.

### General Considerations.

The surgery of the chest is at present only in its infancy, and operations on the thoracic viscera are still comparatively rare because many diseases, which in other parts of the body are easily accessible, when within the thorax are considered to be beyond the reach of the surgeon.

The thoracic viscera are contained within the bony thorax, and when the pleural cavity is opened the lung collapses and a pneumothorax results. If both pleural cavities are opened at the same time both lungs collapse, and respiration cannot continue.

In order to overcome or minimise this risk the efforts of surgeons became directed towards inventing some apparatus whereby respiration or the interchange of gases could be maintained even when the pleural cavity was widely opened.

A brief survey can only be given of the principal methods. These may be divided into :—

1. Positive pressure apparatus.
2. Negative pressure apparatus.
3. Intratracheal insufflation.

The principle of the first two methods of differential pressure, whether positive or negative, is to avoid collapse of the lung and allow respiratory interchange. Where positive pressure is employed the head is enclosed in an air-tight chamber or mask to which air is supplied at a slightly higher pressure than that of the atmosphere. In employment of negative pressure the use of a large pneumatic chamber is necessary which encloses all but the head of the patient ; in this the operator and his assistant have to work, and communication has to be made with the anæsthetist, who remains outside. The air in the chamber is exhausted with a pump until it is at a slightly lower pressure than that of the surrounding atmosphere. Both these forms of apparatus are bulky, expensive, and not easily transportable.

Intratracheal insufflation depends on the fact that the interchange of gases can be maintained without the movements of respiration by passing into the trachea a tube down which is pumped a stream of air ; in this way the vessels of the lung remain aerated and the carbonic acid gas is got rid of. At the same time it is easy to pass the stream of air over the surface of ether so that the patient may be anæsthetised as well. This apparatus has the merit of being simple, cheap, and easily carried. Though it has succeeded well in the case of animals, as far as the writer knows it has not been put to the supreme test in man when both the pleural cavities have been opened at one and the same time.

Experience gained during the war has shown that at any rate one pleural cavity can be opened under ordinary anæsthesia without undue risk to the patient. The tendency of surgeons at the present time is to abandon all forms of pressure apparatus ; it is still too early to state definitely that they will no longer be required.

## Injuries of the Chest Walls.

**Contusions** may be produced by any sort of violence applied to the chest, and may be attended with laceration or rupture of the muscles, or extravasation of blood into the tissues. They owe their chief importance, however, to the fact that they may be complicated by a serious injury to the contained viscera, such as contusion or laceration of the pleura, lung, pericardium or heart, or rupture of a large mediastinal vessel.

**Compression of the chest.**—Constriction or compression of the chest, with or without fracture of ribs, such as may occur in a densely-packed crowd, may cause suffusion of the head and neck and subconjunctival hæmorrhages, the whole face becoming swollen and of a bluish-black colour, rendering the patient's features unrecognisable ("surgical asphyxia"). This is attributable to over-distension of veins and capillaries, owing to the absence of valves in the jugular and facial veins. The injury at first appears very alarming, and there may be marked shock, but if the thoracic viscera are not injured the condition rapidly improves, the suffusion disappearing and the extravasated blood being absorbed.

**Fracture of the ribs** is generally due to external violence, rarely to muscular action. External violence may be (*a*) direct, such as that caused by the kick of a horse or a fall upon the edge of a table: the fracture then occurs at the seat of injury, the fragments being driven inwards and occasionally injuring the thoracic or more rarely the abdominal viscera, such as the liver or kidney, or the diaphragm; (*b*) indirect, as in severe compression of the chest in a crowd: the fracture then generally occurs about the angles of the ribs, their most convex part, and several bones are usually broken; (*c*) muscular action: the ribs are sometimes broken in this way during violent coughing or from straining during parturition.

Fracture of the ribs is more common in the middle-aged and old than in the young, on account of the loss of elasticity as age advances. The middle ribs (fifth to eighth) are those usually affected; the first and second ribs being protected by the clavicle, and the eleventh and twelfth being movable, are not often broken. Fracture of the upper ribs is more serious than fracture of the lower, as the lung is more liable to be injured.

*Signs.*—Severe pain is felt over the seat of the fracture, and is increased on taking a deep breath or coughing. Fracture of a single rib is very difficult to detect, as there is very little displacement; if several ribs are broken, generally some irregularity of alignment is noticed. Crepitus is usually felt if the flat of the hand is placed over the seat of the fracture, or it may be heard with the stethoscope when the patient takes a deep breath. Surgical emphysema—diagnosed by a crackling sensation something like that produced by rubbing the hair between the fingers—may at times be felt on touching the part. It is nearly always due to a wound of the lung, the air being drawn into the pleura through the visceral layer during inspiration and forced through the wound of the parietal layer into the subcutaneous tissue during expiration. In uncomplicated fractures the ribs usually unite without difficulty, seeing that there is little displacement, the ends of the bones being kept in position by the uninjured ribs above and below. It is noteworthy that the movements necessarily accompanying respiration are not inimical to the healing of fractured ribs provided that the ends are in apposition, though a considerable amount of callus is usually formed.

*Treatment.*—The patient should be kept in bed and the injured side strapped with strips of adhesive plaster so as to control the respiration on that side

and give as much rest as possible. If the lung has been injured, the chief danger lies in a subsequent infective pleurisy and broncho-pneumonia.

*Complications.*—Fracture of the ribs may be complicated by an external wound, a wound of the pleura and lung, or pericardium and heart; laceration of a blood-vessel, such as an intercostal artery; penetration of the diaphragm, and more rarely by perforation of the peritoneum and wound of the liver or spleen. Hence it may be followed by surgical emphysema, pneumothorax, hæmothorax, hæmoptysis, hæmopericardium, and later by pleurisy, pneumonia, pericarditis, or peritonitis.

**Fracture of the costal cartilages and separation of the cartilages from the ribs and sternum** is sometimes met with; union occurs by bone in each case. The symptoms and treatment are the same as in the case of fractured ribs.

**Fracture of the sternum** is rare. It occurs usually as the result of some severe injury and is accompanied by fracture of the ribs, injury to the thoracic viscera, and sometimes by fracture of the spine.

*Treatment.*—The displacement, if any, may be remedied by retraction of the head and shoulders, and then the patient should be put to bed in the dorsal position.

**Wounds of the chest walls** may be divided into the penetrating and non-penetrating. The non-penetrating are of no serious consequence and may be treated like wounds in other situations. Penetrating wounds are produced by bullets and by stabs, and may be complicated by wounds of the pleura and lung, the heart and pericardium, or a large blood-vessel such as the aorta, vena cava, or an intercostal or internal mammary artery. If the wound is small and there is no evidence of injury to any of the thoracic viscera, it may be treated as a wound in any other part of the body. If the wound is large and there is evidence of injury to the thoracic viscera as well, then the advisability of an operation for the repair of the injured organs must be considered (see *Injuries of the Thoracic Viscera*).

## Injuries of the Thoracic Viscera.

The organs that may be injured are the lung and pleura, heart and pericardium, and the great blood-vessels.

*Methods of examination.*—Before deciding on the treatment to be adopted in a case of suspected injury to the thoracic organs it is necessary to gain some idea of the nature and extent of the injury. The patient should be stripped as far as the hips and a careful physical examination made of the thorax. The special points for observation are: the nature of the respiration, the position of the heart's apex beat, the presence of fractured ribs, hæmoptysis, hæmothorax and pneumothorax.

X-rays are of great service, for by their means it is often possible to discover more easily than by physical examination the presence and size of a hæmothorax, the position of the heart, and the movements of the diaphragm.

**Injuries of the lung.**—The lung may be injured by crushes, indriven spicules of broken ribs, or by bullets or stabs. A wounded lung bleeds freely, and blood, usually accompanied by air, pours into the pleural cavity, forming a pneumo-hæmothorax. The lung collapses owing to the pressure of the air and blood in the pleural cavity, and unless a large vessel has been injured the bleeding stops automatically. If the amount effused is great the patient is distressed, with cyanosis and hurried respiration; the heart is displaced

to the opposite side, and the movements of the diaphragm on the affected side are impeded.

If there is an external injury communicating with the pleural cavity, air may be sucked in and blown out at each respiratory movement.

**Injuries of the pericardium and heart.**—Contusions, wounds, and rupture of the pericardium may at times be produced by a severe crush of the chest wall, but are more often due to the penetration of a fragment of rib or to a stab or bullet wound. In the last two instances the heart is generally also involved.

*Signs of injury to the pericardium.*—The position and direction of the wound combined with the signs of severe shock and hæmorrhage, and the formation of a pericardial effusion and subsequent pericarditis, point to the diagnosis.

The *treatment* consists in absolute rest, and opium to relieve pain. Should the heart's action become seriously impeded by the effusion of blood, serum or pus, aspiration or free incision and drainage are required. The prognosis is always very serious, the patient dying usually from the effused blood hindering the heart's action, or from subsequent infective pericarditis.

**Injuries of the heart.**—These are almost always due to stab wounds and are commonly instantaneously fatal from shock and hæmorrhage, especially when one of its cavities, and particularly one of the auricles, has been penetrated. Remarkable exceptions, however, occur, and patients have been known to linger for a few days and even to recover. When not at once fatal a wound of the heart is attended with great collapse, syncope, a fluttering pulse, dyspnœa, and later with symptoms of pericardial effusion and pericarditis.

Foreign bodies, such as a knitting-needle or bodkin, when fixed in the heart may be seen to move with the contractions of that organ ; the foreign body should be withdrawn after preparation has been made for treatment of a wound in the heart should occasion require.

*Treatment.*—If the patient survive long enough an attempt should be made to suture the wound in the heart, and for this purpose one or more of the costal cartilages are excised, the pericardium opened, the wound exposed and sutured with fine stitches. A number of cases are now recorded in which this treatment has been successfully performed.

**Rupture of the heart,** though rare, occasionally occurs as a result of great external violence to the chest wall or of some sudden exertion on the part of a patient suffering from fatty infiltration or degeneration of the heart muscle. The rent may occur in any of the chambers, but is found most frequently in the left ventricle on the anterior wall not far from the septum. Death is as a rule almost instantaneous. The sign during life is that of blood in the pericardium.

**Wounds of the large blood-vessels,** whether produced by crushes or stabs, are almost invariably and immediately fatal, and there is no time to attempt any operative interference.

### Complications accompanying Injuries of the Thoracic Viscera.

The immediate complications attending injuries of the chest are—

1. Shock.
2. External hæmorrhage.
3. Internal hæmorrhage, causing hæmothorax.
4. Pneumothorax.
5. Surgical emphysema.
6. Injuries to the diaphragm and abdominal viscera.

**External hæmorrhage** is seldom due to the wounded lung ; it more often

results from an injury to an intercostal artery or the internal mammary artery. Bleeding from these sources may generally be recognised by the arterial blood escaping in jets. Such bleeding must be stopped by ligature when possible, though it may be necessary to excise a portion of rib or costal cartilage to accomplish it.

**Hæmothorax** may occur with or without external injury. The amount of blood effused may vary from a few ounces to several pints. The signs are those of fluid in the chest, but the diagnosis is best confirmed by the X-rays or the aspirating needle. A small uncomplicated hæmothorax may be absorbed completely. If of large size (30 or 40 oz.) it is best evacuated by aspiration or open operation, according to the nature of the case.

**Pneumothorax,** or air in the pleura, in surgical practice is generally the outcome either of a stab or of a wound of the lung by a fragment of a broken rib, resulting in a communication being made between the pleural cavity and the general atmosphere. It is attended with more or less collapse of the lung and may be recognised by tympanitic resonance, absence of breathing sounds, or amphoric breathing, metallic tinkling, and increasing dyspnœa. When combined, as it often is, with a hæmothorax or pleural effusion the lower part of the chest will be dull to percussion, and a splashing sound on shaking the patient may be heard. The air is usually absorbed as soon as the wound of the lung heals, but should the breathing become seriously affected it may be sucked out with an aspirator.

**Emphysema,** or air in the connective tissue spaces, is sometimes called *surgical emphysema* to distinguish it from the medical affection of the same name in which the air cells of the lung are dilated. It is generally due to a crush causing a wound of the lung combined with a laceration of the parietal and visceral layers of the pleura, and is a very frequent complication of fractured ribs. The air either escapes into the pleura at each inspiration, and thence during expiration is forced through the parietal layer into the subcutaneous connective tissue, or it passes, if there are adhesions between the two layers of the pleura, directly from the lung into the subcutaneous tissue. More rarely it is due to a rupture of the lung without injury of the pleura, the air then escaping at the root of the lung into the posterior mediastinum and thence into the connective tissue of the neck and arms. More rarely still it may occur without a wound of the lung, or even without a wound of the pleura, *e.g.*, during labour.

*Signs.*—The emphysema, though usually limited to the seat of injury, may extend somewhat widely around it, and in rare instances has spread over the whole body. It gives rise to an ill-defined flattened swelling unattended with signs of inflammation, and unaltered on inspiration and expiration. On pressing the swelling a peculiar crackling sensation is experienced, like that of rubbing the hair between the fingers.

*Treatment.*—No special treatment is required, the air becoming as a rule quickly absorbed. Should respiration become seriously affected relief may be obtained by the inhalation of oxygen.

**Injuries to the diaphragm and abdominal viscera.**—Penetrating wounds of the lower thorax are liable to injure the diaphragm and the adjacent abdominal viscera, the liver, stomach, and spleen. Wounds of the left half of the diaphragm are apt to be followed by hernia of the abdominal viscera into the pleural cavity. Such a complication is rare on the right side, because the dome of the liver gives protection.

The remote complications attending injuries of the chest are :—

1. Sepsis of the pleura and its contents.

2. Incomplete expansion of the lung.
3. Deformity of the chest.

**Sepsis of the pleura and its contents.**—This is the main danger attending penetrating wounds. Blood lying in the pleural cavity affords a good medium for the growth of bacteria. Empyema and septic broncho-pneumonia are liable to follow, and constitute a very grave danger.

**Incomplete expansion of the lung** results from the formation of adhesions between the collapsed lung and the parietal pleura, which prevent it expanding. The result may be that the lung never functions completely again and the chest wall falls in, leading to permanent deformity.

**Treatment of injuries of the chest.**—Experience in the war has proved that the principles of surgery can be applied to the thorax as to any other part of the body. It has shown that the pleural cavity can be opened widely, an injured lung sutured, foreign bodies and splinters of bone removed, and the chest closed and restored to early function.

This possibility by no means implies that all cases of injury of the chest should be treated by operation. The majority do not require active surgical treatment, and the real difficulty is to decide whether or not to operate.

Speaking generally, non-penetrating wounds do not require operation, unless the injury has driven a large fragment of rib into the lung and clear evidence of this has been gained by the X-rays.

A certain number of penetrating wounds require operation, the main purpose being to prevent the chief complication, namely, sepsis of the pleural cavity. The operation must be done early, before infecting organisms invade the tissues.

The indications for early operation are :—

1. A large wound, such as is caused by shell fragment or bullet, allowing suction of air into the pleural cavity.
2. A ragged wound of the soft parts communicating with the pleural cavity.
3. Compound fracture of the ribs.
4. Retention of a large foreign body in an accessible position.

*Treatment by operation.*—A penetrating wound, if treated by operation, must be treated effectively and completely.

The principles of the operation are as follows :—

1. The external wound, which presumably is contaminated, is excised, and any pieces of broken ribs removed. The pleural cavity, widely opened by a retractor, is then cleaned through the wide opening in the parietes. All the blood is wiped out and all foreign bodies, such as bullets, shell fragments, portions of rib or clothing, removed. Attention is then paid to the thoracic viscera, lung, diaphragm, and pericardium ; these are cleansed and sutured in the same way as in injuries of abdominal viscera. This having been done, the chest wall is closed in layers, pleura to pleura, muscle to muscle, and skin to skin.

*Treatment without operation.*—When none of the indications for early operation are present—that is, when the wounds of the chest wall are small and clean, when there is no evidence of fractured ribs, or when the foreign body retained in the lung or mediastinum is small—the patient is treated on general medical principles. A careful record is kept of the pulse, respiration, and temperature. A hæmothorax, if large enough to produce symptoms, is aspirated ; otherwise the chest is only needled if the condition of the patient suggests that the hæmothorax is becoming infected, when a sample of blood is removed for bacteriological examination.

## Diseases of the Chest Walls.

These include inflammatory and malignant diseases of the bones and soft parts, and are not peculiar to the thorax. Information as regards these should be sought in the sections dealing with the affections of these tissues.

## Diseases of the Pleura and Thoracic Viscera.

**Diseases of the pleura.**—The affections of the pleura which come within the cognisance of the surgeon are mostly those in which an infection has occurred and the pleural cavity become filled with pus. Organisms may reach the pleural cavity in several ways :—

1. By extension from inflammatory diseases of the lungs, *e.g.*, pneumonia or pulmonary abscess ;
2. By extension from suppurative processes in the œsophagus or some of the abdominal organs, *e.g.*, perforated gastric ulcer or ruptured liver abscess ;
3. By the blood-stream, as in generalised tuberculosis or pyæmia ;
4. By penetrating wounds from without.

**Bacteriology of inflammation of the pleural cavity.**—*Pyogenic organisms.*—The commonest organism to be found is the pneumococcus, the reason of which is easy of comprehension, seeing that infection is most likely to arise in connexion with inflammatory diseases of the lungs such as pneumonia, bronchiectasis, or pulmonary abscess. Streptococcal infections, though arising also from diseases of the lungs, are more often found in connexion with spread of inflammation from the abdomen through the diaphragm, which may occur in cases of undrained subphrenic abscess following some cause such as a perforated gastric ulcer or suppurative appendicitis.

*Tuberculous infections* are very common, the tubercle bacillus gaining entry by direct extension from a phthisical lung or through the blood-stream, as in generalised tuberculosis.

*Actinomycosis* is occasionally found as the cause of a very chronic and intractable empyema.

**Signs of empyema** are those of fluid in the chest, namely, embarrassment of respiration, dulness on percussion, and loss of vocal vibrations and local fremitus, combined with the signs of fever and a raised leucocyte count. No single sign, however, exists whereby an empyema may be diagnosed from a serous effusion with certainty. X-rays are of great use, but the exploring needle should be employed in all doubtful cases as a matter of routine and a bacteriological examination made of the fluid withdrawn so as to ascertain the nature of the infection. In making the puncture too fine a needle should not be used, as the pus, especially in pneumococcic infections, is often thick and viscid. Even with a large needle it may happen that a shred of tissue will block the orifice and the puncture apparently be without effect. It is well, therefore, after withdrawing the needle to examine the end carefully for any material which may have entered it. If the pus is free in the pleural cavity it is not very difficult to find it, but if localised to a limited area of the pleural sac or encysted between the lobes of the lung it may be extremely difficult to do so, and thoracotomy may become necessary to allow of free exploration.

*Treatment of empyema.*—The choice of an anæsthetic is an important one, as the patient has always more or less dyspnœa, and the anæsthetic may cause cessation of respiration. If chloroform is chosen only a little should be used, or gas may be given, followed by a little A. C. E. mixture. Intratracheal insufflation may be used, or even a local anæsthetic.

Should the breathing stop, the fluid should be let out forthwith before beginning artificial respiration. The position of the patient is important also: he should not be turned on to the sound side in order to expose the affected one, which seems the natural thing to do, as by this means the already embarrassed respiration would be made worse. It is better to prop the patient up with pillows and have the arm on the affected side held well up, or the patient may be left lying on the back but brought well to the edge of the table so that the surgeon may still work without turning the patient.

The essential object in the treatment is early evacuation of the pus. This may be done through a stab-hole between the ribs, but this method does not allow good drainage, and is not generally adopted.

The usual method employed is the excision of about an inch of rib, followed by drainage.

The line of incision should as a rule be over the seventh or eighth rib in the posterior axillary line, and from 1 to 2 inches of the rib excised. This incision will generally be over the most dependent part of the cavity, and will thus avoid the necessity of a counter-opening, whilst the removal of a portion of a rib in this position has a good effect in letting the wall of the chest fall in. If the incision is made lower, the diaphragm may be wounded, or this muscle may subsequently rise as the pus is let out, and narrow or block the opening; moreover, an empyema does not often extend below the eighth or ninth rib, the lower pleural cavity being shut off by adhesions: if the incision is made higher, the cavity is not efficiently drained. The rib should be removed subperiosteally, so as not to injure the intercostal artery, though if this accident does happen the artery can be picked up and tied without difficulty. The pleural cavity is then opened with a blunt instrument in the middle of the space unless the pleural membrane is much thickened, in which case a knife has to be used. If the empyema has been hit off accurately blood and pus come flowing out, and a finger should be passed into the wound to detach fibrinous masses, break down loculi, and to free the margin of the detached lung so that it may be free to expand as the pressure is relieved. It is generally considered inadvisable to irrigate the cavity of the pleura with lotion, as this manœuvre may be attended by sudden collapse, or some of the lotion may find its way into a bronchus, and even through a bronchus into the opposite side, and so set up bronchitis. The empyema cavity is swabbed out with gauze on long forceps. When the cavity has been emptied the lung often expands almost completely, but it will not do so in long-standing cases in which there are much thickening of the visceral layer of pleura and adhesions between the visceral and parietal coats.

The pleural cavity has now to be drained. Many different methods of drainage have been advocated. The object to be attained is to allow free exit of pus without suction of air into the pleural cavity.

In favourable cases the collapsed lung, if freed of the pressure on it, expands rapidly and soon attains its normal size, filling the chest; adhesions form between the visceral and parietal layers of pleura, and the abscess cavity becomes entirely obliterated.

In the after-treatment the patient should lie on the affected side as much as possible, so as to facilitate drainage, and expansion of the lung be encouraged by the use of special breathing exercises. In favourable cases the sinus heals in a few weeks.

There are indications now that it may be possible to improve on the above traditional method of treating empyema.

*Treatment of empyema by open operation.*—If the infection of the pleural

cavity is not very intense, and if the operation is undertaken at an early stage of the disease, it is possible in certain cases to excise a sufficiently large piece of rib to open the thorax widely, wipe out all the pus, and then to close the chest completely. This method has been successful in a few cases, healing taking place by first intention. It is *sub judice* at present, and is not recommended for universal use.

**Chronic empyema with sinus formation.**—There are many unfortunate instances in which early closure of the empyema cavity is not attained, owing, it may be, to thickened visceral pleura, or adhesions between the two layers of pleura, preventing the lung from expanding. The result is that a space with rigid walls is left between the lung and the parietes. This being infected is covered with granulations, the pleura continues to become more and more thickened, and pus escapes through one or more sinuses or, if the sinus is not kept open, accumulates in the lower part of the cavity, and the empyema re-forms. This condition is very commonly the outcome of a tuberculous infection of the pleural cavity, originating perhaps in phthisis or the bursting of a tuberculous abscess in the lung. As the result of such a long-standing empyema the patient declines in health, becoming anæmic, short of breath, and suffering usually from cough and clubbing of the fingers.

The *prognosis* is grave, for while some are able to continue at work in comparative health for many years, the majority succumb sooner or later to septic infection or amyloid disease.

If the empyema is tuberculous, surgical interference should not be attempted. If non-tuberculous, an effort should be made to secure closure.

*Treatment.*—The object of treatment is to abolish the space between the lung and the parietes, and if it is not possible to make the lung meet the ribs, the ribs must be allowed to fall inwards to the lung.

It is obvious that it is much more desirable to enable the lung to expand, and so close the cavity, than to make the chest wall fall in to meet the collapsed lung, for the latter course means permanent deformity and disability.

*Decortication of lung.*—Failure of expansion of the lung is due to thickening of the visceral pleura and adhesions between it and the parietal layer. The operation of decortication consists in stripping off the thickened layers of pleura, thus allowing the imprisoned lung to expand.

The operation has not been perfected, but much is to be hoped from it.

Failing this, the operation known as "*thoracoplasty*," or *Estlander's operation*, may be undertaken.

This consists in the removal of portions of several ribs, so as to allow the chest wall to fall down on to the surface of the lung, and, the diaphragm pressing up from below, the space will eventually be obliterated. It leaves the patient with some deformity of the chest, and a very intractable form of scoliosis of the spine may result. In consequence systematic spinal exercises must be ordered to counteract this tendency.

## Diseases of the Lungs.

The diseases of the lungs which are amenable to surgical treatment are not many, though perhaps too little has been attempted for the reason mentioned at the beginning of this section, namely, that exploration of the lung necessitates opening of the pleural cavity and the formation of a pneumothorax. With the use of one or other of the means of overcoming this difficulty an exploratory thoracotomy should in time become as safe as an exploratory laparotomy, and then better results may be hoped for.

Before proceeding to open the chest as accurate a diagnosis as possible should be made. The physical signs are often very misleading. The nature of the expectoration should be noted, and it is to be borne in mind that the quantity expectorated bears no constant relation to the size of the abscess cavity. By means of X-ray examination useful information concerning the site, extent and number of the lesions of the lung may be gained, and exploratory puncture with a needle may often render certain the presence and position of an abscess. The operation of exploratory thoracotomy consists in exposing an area of the lung by an incision which is large enough to permit of the resection of 3 inches of two or more ribs or the turning up of an osteoplastic flap of the chest wall. In this operation the ribs are cut through with a pair of shears, the intercostal arteries are ligatured and cut, and a flap of the whole chest wall with the exception of the pleura turned up. The parietal layer of pleura is kept entire and then incised carefully, so that when the operation is completed the pleural cavity may be sutured and then the lung blown up by increasing the atmospheric pressure within it, so that the lung fills the pleural cavity and the artificial pneumothorax produced is obliterated. The ribs may then be sutured by stout catgut sutures passed through holes punched in the ends.

**Pulmonary abscess** may follow an acute infection of the lung, such as septic pneumonia, or be due to the spread of an empyema or bronchiectatic cavity. It may also be associated with gangrene of the lung or be a part of a general pyæmic condition. In the latter instance, being part of a general infection, it is not amenable to surgical treatment. If the abscess is single and not part of a general blood infection, it should be opened and drained in the same manner as an abscess in any other part of the body. Before opening the chest the abscess should be located by the physical signs, skiagrams, and puncture with an aspirating needle. When pus is found the needle should not be withdrawn, but left in position as a guide to the abscess and an incision then made down to the pleura, about 3 inches of a rib being excised. The two layers of pleura will generally be found adherent, owing to the extension of the underlying inflammation. In this case the operation can be proceeded with at once. A director is passed in along the needle and then the wound enlarged with forceps, or a knife and a drainage tube inserted. In this manner the arteries of the lung are not wounded, and no vessels need be tied. Should there be no adhesions between the visceral and parietal layers of the pleura, then the operation is performed in two stages. This first stage is completed by passing a ring of sutures with a fully-curved Hagedorn needle through the substance of the lung, fixing it to the parietal pleura. A few days later, when the pleural cavity is well shut off by adhesions, the abscess may be opened as described above or with a thermo-cautery. Irrigation of a pulmonary abscess cavity is not advised, because such an abscess frequently communicates with a bronchus, and fluid might find its way into this or even into the opposite lung and cause serious trouble.

**Bronchiectasis.**—In this condition there is a dilatation of the bronchial tubes, with the formation of one or more saccular cavities in the lung in which secretions collect and decompose. The condition is a very chronic one, and is characterised chiefly by the coughing up of a large quantity of foul fluid sputum. The abscess may be single or multiple, and both lungs may be affected at the same time. The condition of the patient suffers markedly, a general infection may result, and an abscess of the brain is not an infrequent complication. Bronchiectatic cavities, therefore, are not very amenable to surgical treatment. If only one cavity is present it

may be opened and treated like a pulmonary abscess. It is not likely, however, to be a very permanent cure, as other cavities are liable to follow in the course of the disease. If more than one cavity is present at a time it is hardly feasible to open and drain them all, and as an alternative it has been suggested that the affected lobe of the lung should be excised. Excision of the lobe, though it has been performed, is a difficult and dangerous procedure which is hardly justified.

**Pulmonary phthisis.**—Not very much in the way of operation can be done for this complaint, seeing that the disease is seldom limited to a definite area but extends over a large portion of the lung. In the case of a cavity at the apex of the lung the first and second costal cartilages have been removed so as to allow the chest wall to fall in and yield, as the lung tissue round the healing cavity undergoes cicatricial contraction. It might be advisable to excise a portion of the lung if the disease were strictly limited, and a few operations have been recorded in which the whole of one lung has been excised, in cases where a sort of pultaceous degeneration has followed a long-standing disease. The operation cannot be recommended, as the mortality is so high.

The production of an artificial pneumothorax by introducing sterile nitrogen gas into the pleural cavity is now recommended in certain forms of pulmonary phthisis. The principle of the method is to cause collapse of the lung, and so by putting it at rest to relieve pain and cough.

**Emphysema of the lung** may be treated by resection of small portions of several ribs, either close to the sternum or in the axilla, with the idea of restoring mobility to the rigid chest wall which commonly accompanies this complaint. Technically the operation is easy, the chief complication to be feared being injury to the pleura ; but the operation is not without danger, patients having died from subsequent pneumonia and severe disturbance of respiration.

**Primary new growths of the lung.**—Theoretically these should be treated in the early stage by resection of the portion of lung concerned, but practically they are seldom recognised in a sufficiently early stage to be within the reach of surgery. In the later stages, when there is a pleural exudate, drainage of the chest may relieve the patient by lessening the embarrassment of the pressure of fluid and enabling an irritated lung to collapse. Primary new growths of the lung may be sarcomatous or carcinomatous, and a few rare cases are recorded of teratomata.

**Hydatid cysts of the lung** may be treated satisfactorily by incision and drainage.

## Diseases of the Pericardium.

**Pericardial effusions.**—A large serous effusion may give rise to dangerous pressure on the heart and impede its action. Relief may be afforded by tapping the pericardium. This is done by inserting an aspirating needle through the fifth intercostal space on the left side, either close to the sternum, to the inner side of the internal mammary artery, or about $1\frac{1}{2}$ inches to the outside of the sternum, so as to avoid the pleura.

**Purulent effusions** may be treated by aspiration or by incision and drainage, better by the latter. The differential diagnosis has to be made from dilatation of the heart. The pericardium may be reached by an incision through an intercostal space without excision of a rib, but it is better to excise a portion of a costal cartilage and to have a clear view of the pericardium before incising it. The cavity is then opened and a drainage tube inserted, but it is generally found that the cavity is difficult to drain, and a tube causes

great pain by rubbing against the inflamed surface of the heart. An alternative route, and probably a better one, is that made by incising along the lower border of the left costal margin and penetrating the diaphragm close to its attachment. The embarrassed condition of the heart often forbids a general anæsthetic, and the operation may have to be performed under local anæsthesia.

**Pericardial adhesions.**—The result of a chronic adhesive mediastinitis may be to fix the heart to the anterior wall of the thorax in such a way that it causes increase of strain upon the heart and subsequent hypertrophy. In advanced cases, where it is felt that the patient cannot continue in such a condition, relief may be afforded by the operation known as "cardiolysis," which consists in the resection of portions of several ribs on the left side over the region of the heart and division of adhesions. By these means the enlarged heart is given more room to work in, the rigid bony thorax being replaced by the soft parietes.

## Diseases of the Mediastinum.

These may be divided into (1) inflammatory affections and (2) tumours.

**Inflammatory affections.**—Inflammation of the mediastinum is most commonly due to the spread of infection from cellulitis of the neck below the deep cervical fascia, or follows the perforation of a carcinoma of the œsophagus, and more rarely the spread of infective processes in the lungs or tuberculous disease of the sternum, ribs, or mediastinal lymphatic glands. These complaints are not usually accessible to surgical treatment, and if the inflammation is at all acute the patient usually dies before anything like a well-defined abscess has formed. If an abscess does form, it may point and be opened in one of the intercostal spaces, or it may burst into the pleura, œsophagus, or trachea.

**Tumours.**—These may be sarcomata, new growths arising from the thymus gland, enlarged tuberculous glands, a retrosternal goitre, or in rare instances a teratoma. They may give rise to pressure on the trachea, œsophagus, or large blood-vessels. It is very seldom that anything can be done for the relief of the patient. A few cases have been recorded in which the sternum has been split and the sides of the thorax retracted, so as to gain a view of the anterior mediastinum. Such measures can rarely be successful.

# Section XVII.

## INJURIES AND DISEASES OF THE MAMMARY GLAND.

### Congenital Variations of the Mamma.

Congenital absence of the whole mammary gland is uncommon; unilateral absence is the more usual, bilateral very seldom seen. Congenital absence of the nipple is occasionally noticed. The ducts then make their exit in a shallow depression at the centre of the areola.

Supernumerary nipples are not infrequent. They are usually seen lower on the thoracic wall than the position of the ordinary mamma. They may be unilateral or bilateral, and they may be present with or without an areola.

The presence of more than two mammary glands is much more common than absence of one or both organs. The additional breast (or breasts), like a supernumerary nipple, usually occurs in places where in other female animals it is normal to find a gland: thus, the axilla, the surface of the thorax above or below the normal mamma, the anterior abdominal wall, and the upper part of the thigh.

It is seldom that the accessory mamma is functional, but it may be the site of disease, even of carcinoma.

### Injuries of the Mamma.

The mammary glands from their superficial and exposed position are liable to injury, and particularly in the female.

**Bruising.**—Sometimes among the ignorant they may be bruised in early infancy by manipulation with a view to extracting supposed milk. In adults it is by no means uncommon for badly-placed and rigid corset bones to impinge upon and damage the delicate mammary tissue. Such injury may be the starting point of a chronic mastitis, and there is some evidence in support of the theory that even carcinoma may occur in these damaged areas.

Bruising from a direct blow, such as striking the breast against the edge of an open door, leads to rupture of some of the blood-vessels with which the gland is freely supplied, and considerable hæmatomata may form in the loose mammary tissue. If this collection becomes infected a troublesome burrowing suppuration may follow. In other cases the extravasated blood acts as a foreign body, sets up inflammation, and leads to the formation of a blood cyst.

**Penetrating wounds** of the mammary gland are generally due to stabs, and, on account of the left mamma being over the region of the heart, attempts at homicide more often wound the breast than the heart.

Owing to the vascularity of the gland, a considerable quantity of blood may be lost externally or extravasated into the mammary tissue. It may be necessary in some cases to enlarge the wound and ligature the bleeding point.

**Foreign bodies** in the breast are not infrequent, and commonly consist of needles or pins. These enter the gland tissue either by accident when a needle has been stuck in the blouse or bodice, and then pushed in by subsequent

pressure, or of purpose when a hysterical girl deliberately inserts one or more to enlist sympathy.

An X-ray examination proves their presence, and an incision will allow of their removal.

## Hypertrophy of the Mamma.

True hypertrophy of the mammary gland is a comparatively rare condition. There is a normal developmental enlargement at puberty in the female, and a normal physiological enlargement during pregnancy previous to lactation, but when the term "hypertrophy" is used it is intended to indicate an abnormal increase in size which is not due to the above causes or to a neoplasm.

Such a hypertrophy may take place in the female or in the male. If it occurs in the latter it is merely as it were an abortive attempt to develop a gland similar in size to that which is found in the adult female.

At present there is but little known as to the real cause of the normal developmental enlargement of the gland in the female, though it is probably dependent on some internal secretion, and it is likely that some such influence is the determining factor in the abnormal development in the male. The only treatment of the hypertrophied male mammary gland, if treatment is needed, is to amputate the organ.

Hypertrophy of the female mamma may take place abnormally chiefly at two periods, at or soon after puberty or during or soon after pregnancy. It will at once be seen that again there may be at work one of the obscure factors already mentioned, namely, the action of an internal secretion, augmented both in amount and activity at these particular periods.

It would appear that such hypertrophy is rather more common among Asiatics than in the West. The condition, however, is not to be confused with true elephantiasis, which may affect the breast, but chiefly the cutaneous tissue covering the gland.

## Inflammation of the Mamma.

Inflammation of the mammary gland may be classified as follows :—

1. Inflammation of the nipple.
2. Inflammation of the mamma.
   - (*a*) Acute (infective).
   - (*b*) Chronic (simple).

     (infective : tuberculous ; syphilitic ; actinomycotic).

Every gland which has ducts opening upon a cutaneous surface possesses an open door for infection of its acini. Hence inflammation of the mammary gland is a very common disease.

Infection may also occur through the blood-stream, or it may spread into the breast tissue from adjacent parts. Cysts and new growths of the mamma may become infected.

**Inflammation of the nipple.**—The nipple, projecting as it does from the surface of the mamma, is liable to injury from clothing or handling. It may thus become excoriated, and inflammation from infection may ensue. During lactation the nipple is exposed to a recurring source of damage by the infant's mouth, and, being still more prominent at this time, it is not sufficiently protected or is allowed to remain moist after suckling. The nipple when inflamed becomes œdematous, rigid and tender. Cracks and fissures occur in the outer surface or summit of the nipple, and cause very severe pain, specially during the act of suckling.

Infection of the nipple is a usual precursor of deep-seated infection of the mammary gland; hence its prevention or, if present, its cure is of much moment. The prevention of inflammation of the nipple apart from lactation is simple, being the protection of the projecting part from injury, particularly that of corsets.

The prevention of inflammation of the nipple in connexion with lactation is much more difficult. Prophylaxis should begin before the birth of the child. If the nipple is poorly developed, means should be taken to encourage its greater prominence. The pressure of corsets should be forbidden, a daily application of a breast-pump for a few minutes carried out, and the nightly application of a circular ring of thick plaster recommended, all of which will tend to produce a much more satisfactory nipple. A gentle rubbing over of the nipple with eau-de-Cologne or methylated spirit once or twice a week tends to harden its cutaneous surface and so to prepare it for the attacks of the infant during suckling.

During actual lactation much care must be exercised by the mother in keeping the nipple (and the infant's mouth) scrupulously clean, and in drying the surface of the nipple directly after the child has been nursed. If inflammation has occurred, the child should not be allowed to suck, but the milk should be regularly withdrawn by the breast-pump, and the surface of the nipple kept clean and dry. Washing over with a weak antiseptic such as boracic acid, followed by some spirit, and then protecting by ointment, which may contain some eucain if there is much pain, will usually speedily bring about much benefit.

Intractable cracks or fissures sometimes heal quickly if a silver nitrate stick is applied to them.

While discussing inflammation of the nipple, the fact that it may be infected by the *spirochæta pallida* has to be borne in mind.

A *chancre on the nipple* is rare, but met with frequently enough to be thought of whenever a suggestive sore is seen on the nipple or in its immediate neighbourhood, even in a woman in whom it might be least suspected. The commonest method of infection is by the nursing of a syphilitic infant. Hence wet-nurses are prone to be victims. It is very rare for a mother to be infected by her own paternally infected syphilitic child, for the woman is usually infected already by her husband. Any contact of the nipple, especially if such contact produces a slight wound, with the discharge from a primary sore or secondary lesion is liable to cause inoculation. Induration of the nipple is marked, and may spread into the region of the areola. The axillary lymphatic glands are enlarged, usually with a considerable amount of peri-adenitis and œdema. Soon a secondary syphilitic rash makes its appearance, and the diagnosis is certain.

The *local treatment* is a mercurial ointment, while the *general treatment* is based upon approved antisyphilitic remedies.

**Mastitis, or inflammation of the mamma.**—Because the ducts which open on the summit of the nipple are in direct communication with the acini of the gland, it is easy for bacteria to pass from the surface into the depths of the mamma. Hence inflammation of the breast is common, and more especially during the early and late stages of lactation.

*Acute infective mastitis* is due to the invasion of the acini by cocci, usually staphylococci. The retained milk, kept at body heat, forms an excellent nutrient medium for their development. As they multiply it will be seen that, should the infant be nursed from the affected breast, thousands of cocci will pass with the milk into its intestinal tract and will tend to produce an

acute enteritis. The history of a case of acute mastitis is generally as follows:—The nipple of an active breast has been sore for several days, when the patient begins to complain of pain, rather deeply seated, in the breast itself. The gland becomes indurated, tender, and the skin over it œdematous. Palpation reveals increase of heat and produces considerable pain. If some milk be obtained from the breast and submitted to bacteriological examination, the presence of the bacteria is readily demonstrated.

Simple retention of milk, even when it causes great engorgement of the mammary gland, does not of itself produce inflammation, and still less an abscess, of the breast. Such a condition quickly and decisively yields to the withdrawal of the milk by a breast-pump, and massage. The glands in the axilla may be enlarged, tender and painful, and the general temperature may be raised.

Acute inflammation of the mamma due to bacterial infection frequently passes on into suppuration, with the formation of an acute abscess. Greater enlargement of the mamma will ensue, the pain experienced by the patient becomes throbbing in character, the superficial œdema more pronounced, and fluctuation may be detected. The temperature often rises to 103° F., and the patient may experience a slight shiver or a pronounced rigor.

The *treatment* of acute mastitis is in the first place to prevent it by treating any inflammation of the nipple, secondly to reduce any actual mastitis before suppuration occurs, and thirdly, if pus has formed, to evacuate it at the earliest opportunity.

When mastitis is present and before suppuration occurs, the application of a 5 per cent. lead and opium lotion, frequently changed, may allay the inflammation and lessen the pain, the mamma at the same time being supported. If this treatment is to be carried out for a lactating breast, the infant should not be placed to the nipple on either side, and possibly the breast-pump may be used. In some cases, even before pus forms, a free incision into the mammary tissue gives great relief, and may prevent suppuration.

When pus is present the sooner it is evacuated the better. The patient should be placed under a general anæsthetic, the influence of which may be required for at least ten minutes. A free incision radiating from the nipple should be made deeply into the mammary tissue. In the smaller abscesses, the evacuation of the pus and the maintenance of free drainage by means of a tube through the primary incision is all that is needed. On the other hand, if the abscess cavity is large or deeply seated, it may be necessary to make one or more counter-openings for efficient drainage.

In suppuration in the mammary tissue boldness in evacuating the pus is of the greatest value, for if the abscess is allowed to extend the surrounding breast tissue is rapidly involved and much destruction will result. Further, if the opening be not large enough or the drainage insufficient and not in the most dependent position, a sinus is apt to form which is very difficult to heal. In neglected cases the mamma may become riddled with sinuses, and the only sure method to bring about a cure is to remove the whole breast.

In a retromammary abscess the breast should be drawn towards the sternum and a free incision made along the anterior axillary border superficial to the pectoral muscle. If the pus has invaded the axilla, or the lymphatic glands in the armpit have suppurated, then the space must be freely opened and well drained. Some retromammary abscesses are secondary to tuberculous disease of a rib.

**Chronic simple mastitis.**—Chronic inflammation of the mammary gland is a condition which is frequently seen in the breast of the female.

The inflammatory process is characterised by the formation of fibrous tissue, which, causing compression of the acini and ducts, may bring about their atrophy and even obliteration. If the ducts are obliterated before the secretory power of the cells of the acini is lost, cysts will form.

Such chronic mastitis may affect a single lobule of a gland, or may involve the whole mamma. It is common to find both breasts similarly affected.

*Etiology.*—While it is true that chronic inflammation and the formation of scar tissue with subsequent induration of the mamma may follow acute infective inflammation, by far the larger number of cases occur without such a previous condition.

Commonly chronic inflammation and the formation of an increased amount of fibrous tissue are due to the irritation of toxic products brought by the blood to the affected tissue.

Chronic mastitis is observed in the unmarried, but more often in women who have borne children. It is most prone to occur after forty years of age, and not infrequently near the menopause.

It is possible that the physiological changes through which the mamma passes may have a tendency to produce alterations in the tissue akin to those produced in what is termed "chronic inflammation." This is peculiarly liable to occur when pregnancy has been interrupted, as when abortion has occurred.

Many cases are seen, especially those in which cysts are formed, in women who habitually have trouble with the large intestine, and particularly in those suffering from definite intestinal stasis. These patients appear to absorb an intestinal toxin which has a selective action on the connective tissue of the mammary gland, inducing an interstitial mastitis, and consequently pressure upon ducts and the formation of cysts.

Chronic mastitis presents itself sometimes very obviously, but at other times in a somewhat obscure manner. In typical cases, the hand when laid flat against the affected mamma with the patient in the semi-recumbent position does not discover any definite tumour, but manipulation of the mammary tissue between the fingers and thumb reveals masses of indurated tissue with a feel closely resembling that of a new growth. These masses are frequently multiple and bilateral. Besides the pain of which the patient complains, there may be distinct tenderness elicited by pressure. It is very rare to find retraction of the nipple, puckering of the skin, and enlargement of axillary glands, but all these conditions, suggestive of carcinoma, may be present; hence the great difficulty in diagnosis in some instances.

Where doubt exists the mass should always be explored and a portion submitted to "fresh" microscopic section, the patient's permission having been obtained to proceed in accordance with the histological characters found. To "watch" an uncertain case is unscientific and often fatal.

Chronic mastitis is difficult to treat. The general health of the patient and the functions of the colon must be brought into as normal a condition as possible. Locally the mammary gland should be supported by a well-applied bandage, and even actual pressure by strapping may be adopted.

**Tuberculosis of the mamma.**—The mamma may be infected with tubercle bacilli either primarily or secondarily. The primary lesion is one type of chronic inflammation of the gland, while the secondary affection is an extension of tuberculous infection from surrounding tissues such as a rib (when it often takes the form of a retromammary abscess) or the axillary glands, or it may be part of a general tuberculous affection.

*Primary tubercle of the mamma* occurs in about 1·5 per cent. of cases of mammary disease, but it is very rare before puberty, and becomes uncommon

after the menopause. It is, therefore, most commonly seen between twenty-five and forty, and four times as frequently in married as in single women. It is hardly ever seen in males. Infection may occur through the blood-stream or through the nipple. There is seldom a history of injury, but of a previous attack of inflammation not infrequently. As a rule only one gland is involved.

*Signs and symptoms.*—The disease may be very chronic and localised to a solitary nodule or two of tuberculous deposit, or it may be more acute, the foci of infection quickly coalescing and the whole gland becoming involved. There is seldom any marked retraction of the nipple during the disease, but it may be drawn in when cicatrisation occurs. The pectoral muscle may become involved, while the axillary lymphatic glands are generally infected and become enlarged.

Sometimes the involvement of the lymph nodes exceeds so greatly that of the mammary tissue as to give rise to the supposition that the breast has been secondarily infected from the glands, and this more especially if the upper and outer quadrant of the breast is the site of the disease.

As the tuberculous deposit or deposits increase in size caseation and softening occur and the skin becomes implicated; abscesses then form, frequently break through, and sinuses result. Sometimes the destruction of breast tissue is so great as to imperil the function of the organ.

With regard to *diagnosis*, a single firm, deep-seated nodule, particularly if there is slight retraction of the nipple and some enlargement of axillary lymph glands, is very difficult to differentiate from a carcinomatous deposit. Testing with tuberculin may be of some assistance in arriving at a decision, but any doubt should be cleared up by an exploratory incision.

Actinomycosis simulates tubercle in the breast, but the presence of the ray fungus in any discharge and the absence of reaction with tuberculin separate the two diseases from one another.

The *treatment* of tubercle of the mamma is only satisfactory when the gland and its adjacent lymphatics are completely removed. It is possible that in a few cases a partial resection of mammary tissue, especially when the infection is localised to the upper and outer quadrant, together with a clearing out of the glands in the axilla, may suffice to rid the patient of her trouble.

**Calcification of the mamma.**—A few rare cases are on record in which calcification has occurred in the mammary tissue. This may be connected with tuberculosis, especially if the condition has been very chronic. In one case it was seen after the patient had been taking a considerable quantity of calcium lactate in a case of obscure hæmorrhage from the bowels.

**Actinomycosis of the mamma.**—Primary actinomycosis of the breast is exceedingly rare. The gland may sometimes be involved secondarily from actinomycosis of the thoracic wall following upon an intrathoracic infection. It has been seen in the male.

Primary infection occurs through the nipple, and some time after infection a slow induration of the breast is formed, with but little pain. Later the skin becomes involved, gives way, and discharge is exuded. It is the presence of small yellowish masses, consisting of the ray fungus, in this discharge which clears up the diagnosis. The condition may be mistaken for tubercle. The axillary lymphatic glands are not generally enlarged. Persistent sinuses result, and sometimes the whole gland becomes infiltrated with the fungus, being converted into a firm mass, with numerous discharging apertures.

Complete amputation of the mamma is the only certain remedy for the disease if it is at all advanced. This will also prevent any chance of metastasis.

In the early stages large and increasing doses of iodide of potassium may bring about a disappearance of the affection.

## Cysts of the Mamma.

Cysts of the mammary gland may be classified as follows:

A. Innocent.
B. Malignant.

A. Innocent:—
1. Retention cysts:
(*a*) Serous cysts.
(*b*) Galactoceles.
(*c*) Sebaceous cysts.
2. Cysts of new formation:
(*a*) Cystic adenoma.
(*b*) Hydatid cyst.
(*c*) Blood cyst.
3. Cyst of congenital origin:
Dermoid cyst.

All these cysts are benign.

B. Malignant:—
1. Cystic sarcoma.
2. Cystic carcinoma.

1. **Retention cysts.**—(*a*) (i.) *Sero-cystic disease of the mammary gland.*—This disease is characterised by the formation of a number of cysts in the mammary tissue. It is generally associated with a chronic mastitis, frequently being a termination of this inflammation, the contraction of scar tissue leading to the retention of fluid in the acini. This cystic condition is not common before the age of thirty, and is seen chiefly in the breasts of women who are single, or childless, or who have not been able to suckle their children.

The affected breast—or breasts, for both may be involved—is somewhat enlarged, and tends to feel bossy. Here and there a distinct elevation of the skin may be seen. The consistence of the gland varies in different parts, and in some places definite fluctuation occurs. A slight, brownish discharge from the nipple is not uncommon. The contents of the cysts are turbid, often greenish or brownish in colour, but without blood. It is probable that the condition may be a forerunner of carcinoma.

The *treatment* of this condition when marked is amputation of the breast, because it is practically impossible to dissect out all the cysts, and because of the undoubted likelihood of carcinoma ensuing.

(ii.) *Single serous cysts of the mammary gland.*—These are frequent. They are caused by the accidental blockage of one duct and the consequent retention of the fluid in an acinus.

They occur in the non-active mamma. The diagnosis is generally plain, because they are single, smooth and painless, but difficulty may arise when they are deep-seated and tense.

The only *treatment* is to excise the cyst from the mammary tissue.

(*b*) *Galactoceles.*—These are retention cysts occurring in the active lactating breast. They are rare. Three varieties are usually described.

The first, in which a quantity of ordinary milk is held up in a lobe of the mammary gland by the occlusion, generally the outcome of inflammation, of the duct. It presents itself as a pear-shaped, fluctuating swelling distinctly raising the skin over it. Sometimes the cyst grows to a large size. Firm pressure on this part of the gland may occasionally cause the obstruction

in the duct to be swept out and a spurt of milk to be forced through the nipple, and thus the diagnosis is confirmed. This tumour is an ordinary galactocele.

The second type is one in which such a cyst as the above has formed, and then by the gradual absorption of the liquid part of the milk a cheese-like mass is left, constituting a caseous galactocele. As the inspissation advances the swelling becomes more and more solid.

In the third variety an ordinary galactocele forms, and then, owing to the pressure within the cyst or on account of external force, the cyst-wall gives way, and the milk is extravasated into the mammary tissue. This is a diffused galactocele.

The first two forms of galactocele are best treated by excision, if possible after lactation has ceased. If the operation has to be carried out during the activity of the gland, it must be borne in mind that large vessels will of necessity be severed and considerable bleeding occur unless it is adequately prevented.

(*c*) *Sebaceous.*—The areola is well supplied with large sebaceous glands,

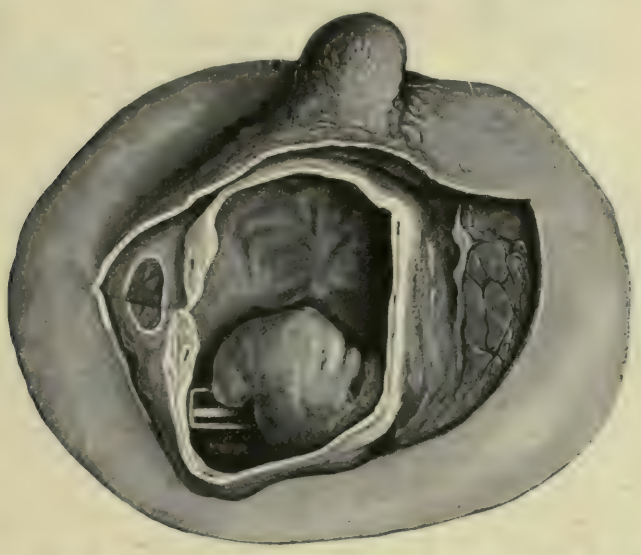


FIG. 326.—Cystic adenoma of the breast. (St. Bartholomew's Hospital Museum.)

and these, as similar glands elsewhere, may develop cysts due to the blockage of their ducts. Such sebaceous cysts may suppurate and cause a supramammary abscess. The *treatment* of an areolar sebaceous cyst is excision, whether inflamed or not.

2. **Cysts of new formation.**—(*a*) *Cystic adenoma.*—A cystic adenoma of the mamma is a tumour which is in the main an adenoma, that is, an innocent growth composed of glandular tissue, but the acini tend to become dilated because they are distended with fluid. If such a swelling is cut across the cyst will be seen to contain a definite mass of adenomatous tissue springing from its wall and more or less filling its cavity.

These tumours occur in women during the child-bearing period of life, and if left untreated grow to a considerable size. They present an enlargement of the breast, which is somewhat irregular in its appearance and often with considerable differences in the consistency of its different parts; thus one portion may obviously fluctuate and another part present all the characters

of a solid tumour. Sometimes fluid can by pressure be made to exude from the nipple, showing that the interior of the cyst communicates with a milk-duct.

If the case is left without treatment by operation, the intracystic growth will tend to increase in amount, and may burst the confines of the cyst itself, or may even cause necrosis of the overlying skin and fungate. While such cystic adenomata are undoubtedly innocent in their early days, it is possible that they assume " sarcomatous " characteristics later, or at any rate appear as if they are malignant when they protrude through the skin.

The *treatment* of these tumours is removal of the whole breast. If this is done there will be no " recurrence " of the disease, but if portions of the breast are left it is always possible that they may become the site of similar growth.

Another form of cystic adenoma is the duct papilloma. A small cystic tumour forms near the nipple beneath the areola. A blood-stained discharge can be obtained, but there is no surrounding induration. It should always be removed as soon as observed.

(*b*) *Hydatid cyst.*—A cyst dependent upon the lodgment of a tænia embryo in the blood-vessel of the mammary gland is exceedingly rare in Great Britain, but somewhat more frequent in Australia, where hydatid cysts in general are much more common. Some of the cases recorded have been in reality hydatids in the subjacent pectoral muscle, eventually involving the mammary tissue by extension.

When in the breast itself they appear as painless, firm, mobile, tense, fluctuating tumours, but so tense may they be at times as closely to simulate a solid growth.

It is of course impossible to be certain of the nature of the cyst, though the occurrence of another hydatid elsewhere renders the suspicion almost a certainty. Withdrawal of fluid by puncture and the presence of hooklets settles the diagnosis.

A mammary hydatid cyst may suppurate, and the discharge of daughter cysts or shreds of cyst wall after perforation of the skin is diagnostic of the nature of the disease.

The proper *treatment* is careful dissection of the cyst out of the breast tissue, or, if infected, an incision with clearance of the contents, and drainage.

(*c*) *Blood cyst.*—A hæmatoma of the mamma after an injury may lead to a permanent blood cyst in the breast. This may be difficult to diagnose unless the history of the case is known, when it should be clear. The fact that there has been considerable bruising of the mamma, and that when this bruising cleared up a fluctuating swelling was left, shows the nature of the lesion. The proper *treatment* is excision.

Cavernous nævi, or angiomata, occasionally occur in the breast.

3. **Cysts of congenital origin.**—A dermoid cyst of the mamma is the only one which can have a congenital origin as far as is known. It is questionable whether a true sequestration dermoid has ever been found in the mammary tissue. Most of the cases of so-called " dermoid " have been deep-seated sebaceous cysts or inspissated galactoceles.

## New Growths of the Mamma.

### 1. Innocent New Growths.

**Fibro-adenoma of the mamma.**—A tumour consisting of fibrous tissue, with here and there scattered through it some adenomatous elements—a fibro-adenoma—is, next to a carcinoma, the commonest new growth in the

mamma. It is discovered usually in young women, frequently unmarried, as a single firm swelling, freely movable in the breast tissue, with the skin quite separate from it. It gives rise to but little pain, though it may become tender just before or during a menstrual period. The presence of the growth is apt to cause a considerable amount of mental anxiety, since its possessor often imagines she has "cancer." The growth is slow, and it seldom attains a size larger than a walnut. The upper and outer quadrant is the most common segment of the breast to be affected, and often the growth is quite in the periphery of the gland.

When a fibro-adenoma is cut across the tissue is found to be very firm, but not so hard as a scirrhus.

The cut surface exhibits a fibrous appearance, much like that observed when a fibromyoma of the uterus is sectioned. Microscopically, it will be found that the proportion of fibrous to glandular tissue varies greatly. The firmer and harder the growth, the greater the fibrous element and the less the adenomatous portions.

If the glandular tissue predominates the tumour may be classified as an adenoma, but if the glandular elements are practically absent, then the growth is a fibroma; while when the fibrous tissue forms the bulk of the neoplasm together with a little glandular tissue, then the term "fibro-adenoma" is used.

FIG. 327.—A fibroma of the areola of the left mamma with a long pedicle. (Maxwell.)

A fibro-adenoma is sometimes associated with the formation of cysts, but these cysts do not contain any intracystic growth. With the development of a cyst or cysts the increase in size of the swelling may be much more rapid.

In a few cases a fibro-adenoma has been known to undergo a malignant change and become the seat of a carcinoma. This complication, though very rare, must always be borne in mind, and is one of the reasons for urging removal.

*Treatment.*—As there is very little evidence for the belief that fibro-adenomata disappear spontaneously, and since they may cause a good deal of mental distress and there is a possibility of malignant elements appearing in them, their removal is indicated.

By the excision of the growth the patient is freed from the presence of a worrying swelling, and the exact nature of the tumour can be determined by the microscope, and permanent relief can be given.

The resulting scar need not be disfiguring, if the incision is made in the proper position and aseptic healing is obtained.

Although a small growth may be removed under a local anæsthesia, it is usually best to give a general anæsthetic.

In fibro-adenomata of the upper and outer quadrant the incision should be made along the axillary border of the mamma and the breast tissue divided until the actual surface of the growth is exposed.

These tumours are encapsuled, so that if the right plane is reached they will shell out.

It is very important to secure all bleeding points, especially where a considerable quantity of breast tissue has been severed.

When the depths of the wound are dry, the cavity should be obliterated by approximating its sides by sutures, a reconstruction of the breast being brought about and very little deformity left.

The edges of the skin must be united with the greatest accuracy. Healing is sound in a week.

**Fibroma of the nipple region.**—Sometimes a more or less pedunculated tumour grows either from the nipple itself or from the areola. This type of growth is usually a soft fibroma. It commences as a somewhat warty elevation which gradually becomes constricted at its base, and later, its weight causing it to drag, produces considerable elongation of its stalk.

Removal is the proper line of treatment.

**Lipoma of the mamma.**—Although the mamma is usually well supplied with fatty tissue in the spaces between the lobes, it is uncommon to see true lipomata. They occur in the mammary substance, in the subcutaneous tissues over the mamma, and in the retromammary area.

The tumour may be single, or there may be more than one associated with the one breast.

Intramammary lipomata may grow to a large size, and without causing much inconvenience, except by their weight. Sometimes in their early stages the patient experiences a good deal of pain, and this may lead to their being considered of serious import. Generally the swelling is encapsuled, and presents itself as a rounded, fairly firm tumour, which shows no sign of malignancy.

The diagnosis has usually to be made from cysts, or from galactoceles with caseous contents.

The supramammary lipoma is usually readily diagnosed, as it presents most of the characters of an ordinary subcutaneous fatty tumour.

The retromammary (paramammary) lipoma develops in the fatty tissue lying deep to the breast and in front of the pectoral muscle. It pushes the mamma forwards or to one side, so that unilateral deformity is marked.

Lipomata are innocent, but their removal is generally advisable.

When intramammary, amputation of the gland may be necessary, but if possible an attempt should be made to excise the tumour from the surrounding tissue. Supramammary fatty tumours are easily excised. Retromammary lipomata can be removed by a crescentic incision on the outer side and by turning the mamma forwards, with replacement after the tumour has been taken away.

In some cases, especially about the menopause, the mammary glands tend to become the site of the deposit of a large quantity of fatty tissue. If such a tendency begins to show itself and is not desired, an attempt may be made to lessen it by prescribing iodide of potassium or thyroid extract internally, and the application of iodine and soap ointment externally. Support by a properly applied bandage should also be given.

## 2. Malignant New Growths.

**Carcinoma of the mamma.**—One half of the growths in the mammary gland are of the nature of carcinoma. This fact alone shows the great importance of such a condition. Carcinoma attacks the mamma in the female far more frequently than in the male. It is somewhat difficult to be certain of the exact proportion between the two sexes, but for practical purposes it may be taken that the female is attacked in at least eighty cases to one in the male. Carcinoma of the female mamma is most frequently seen between the ages of forty and fifty years, but it may occur as early as twenty and as late as ninety.

As to the side most frequently affected there appears to be very little difference; if there is any, it is probable that the left side is more usually the site of carcinoma than the right. Both mammæ may have a carcinomatous deposit at the same time.

The upper and outer quadrant of the mamma is the commonest place for cancer to start, then the lower and outer, then the upper and inner, and lastly the lower and inner. Accessory mammæ may be the site of malignant disease.

*The causation of mammary carcinoma.*—The mammary gland is essentially an epithelial organ, developed from epithelium, and with its acini and ducts lined everywhere with epithelium. It is not, therefore, surprising that it is so frequently the seat of malignant neoplasms of the epithelial variety. There are three distinct types of epithelium found in connexion with the gland. The most superficial is the stratified epithelium met with covering the nipple and the areola; from this is derived typical epithelioma. The somewhat deeper epithelium is that lining the series of ducts leading up to and passing through the nipple on to the surface. The cells of this epithelium are more or less cubical in shape, and give origin to the so-called "duct carcinoma." Deeply placed within the gland and lining the acini is the spheroidal epithelium, which so commonly gives rise to the scirrhous and encephaloid varieties of spheroidal-celled carcinoma.

There can be but little doubt that a preceding chronic mastitis is a powerful predisposing cause of carcinoma of the mamma. It is probable that the tissue of the mammary gland in which an epithelial growth occurs was not normal at the time of the commencement of the malignant disease.

The chief factors in the causation of mammary carcinoma may be summed up as follows:—

*The female sex.*—Probably owing to the larger size of the gland in the female, its periodical functional activity, and to the greater incidence of disease of other kinds in the female breast.

*Middle age.*—This is the period in which carcinoma is most commonly seen in other organs, and it may indicate that there are some insidious changes taking place in the epithelial tissue which render it more liable to the onset of "cancer." Women suffer most from carcinoma at or after the menopause.

*Marriage.*—Eighty per cent. of women who are the subjects of mammary carcinoma have been married, and at least 70 per cent. of these have borne children.

*Irritation.*—There is some evidence, which cannot be overlooked, that carcinoma has appeared at the actual spot where a badly-fitting corset has impinged upon and irritated the breast tissue. This may be taken as a type of irritation to which the breast is greatly liable.

*Traumatism.*—Many female patients will give a history of an antecedent

traumatism, and in some instances the connexion would appear to be so clear that it cannot be disregarded.

*Heredity.*—There may be a close connexion between the disease occurring in mother and daughter; in fact, there appears to be something in the actual epithelium of the family which causes it to be liable to the incidence of carcinoma. In a series of cases of carcinoma of the mamma, a family history of malignant disease will be forthcoming in about 20 per cent.

*Benign neoplasms.*—There is now definite evidence that innocent tumours of the breast do occasionally take on malignant characteristics, but it is not known why they do so. The fact, however, that an innocent tumour may in itself be an irritant is significant. It is a strong plea for the removal of all tumours from the mammary gland—at any rate, when the patient is over forty years of age.

**The varieties of carcinoma of the mamma.**—In their early stages the varieties of carcinomata derived from the epithelium of the acini of the

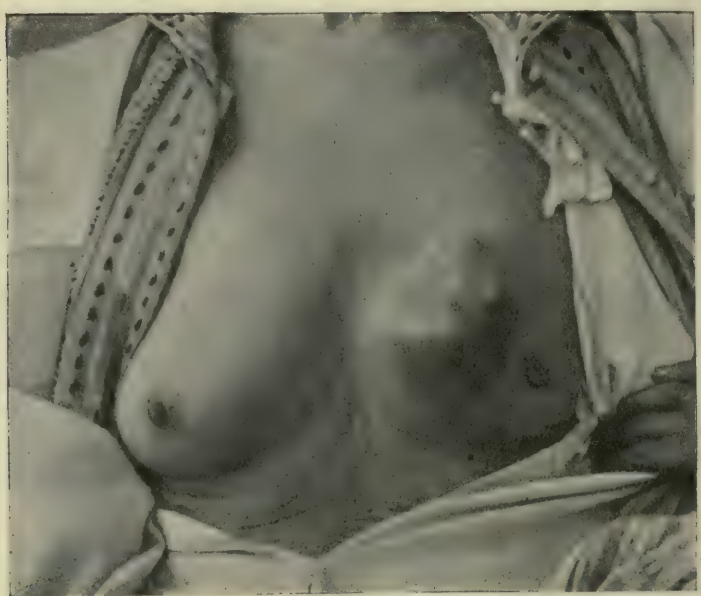


FIG. 328.—Carcinoma of the left mamma with hæmorrhage into the growth.

mamma cannot be differentiated except by microscopic examination, and indeed even in their more advanced stages such examination may be necessary to show to which variety the growth belongs.

Histologically there will be found growths with a relatively large proportion of fibrous tissue, and clinically these are very hard to the touch; they are aptly termed *scirrhous* tumours.

Again, there occur growths in which the cellular element predominates and the tumour is much softer; these have been designated *medullary* or *encephaloid* cancers.

Where in a scirrhous carcinoma the fibrous tissue tends to contract, and the growth apparently therefore to shrivel, the term *atrophic scirrhus* is used. Sometimes cysts, due to degeneration of or hæmorrhage into the growth, form, and this type may be termed a *cystic carcinoma.*

Occasionally the epithelial cells of a mammary growth undergo a colloid or mucoid degeneration, and a *colloid carcinoma* is formed.

When the epithelial cells lining the ducts of the breast give rise to a carcinoma, the growth is termed a *duct carcinoma*.

When it is the epithelium of the skin covering the nipple which is the origin of the growth, a surface *epithelioma* is present.

**Examination of a patient in a case of suspected carcinoma of the mammary gland.**—A patient presenting herself with a swelling in the mammary gland is in great fear that the growth is "cancer," and a definite diagnosis is all-important to her and to her friends from every point of view. That this diagnosis should be made at the earliest possible opportunity is essential, and a thorough knowledge of the methods of examination of such a case is very necessary.

*The position of the patient.*—She should be semi-reclining, with her spine well supported, in the early stages of the examination, but later she should be flat upon her back.

*The position of the surgeon.*—He should stand directly in front of the patient at first, so as to view both the glands, and then he should pass behind the patient for the digital examination.

By *inspection* may be elicited the following facts:—Retraction of the nipple on the affected side (but it must be always remembered that this is a late sign, and therefore not one to be waited for); irregularity on the surface of the mamma, such as dimpling or wrinkling of the skin; actual elevation of a portion of the gland itself, giving rise to a definite tumour; discharge from the nipple, particularly on squeezing the gland.

By *palpation* much may be learnt. The examining hand should pass over the shoulder on the side opposite to the suspected mamma. The fingers should roll the breast tissue under them, not pick it up. Nodules, indurations, and even irregularities can in this way be readily felt. It is important to determine whether there is more than one affected region in the mamma, as a multiple lesion is much more likely to be of an innocent character. Palpation will also give some indication of the actual feel of the growth itself; a hardness, markedly different from the surrounding mammary tissue, with its edges not too distinct, is strongly suspicious of a carcinoma. A crinkling, creasing, or retraction of the skin over the swelling when it is fingered is most characteristic of malignant disease, and indicates that the deeper-seated growth is becoming attached to the overlying skin through the fibrous septa. If the nipple is drawn away from the tumour and a cord-like band is felt running between the two, it is very suggestive of carcinoma.

The examining hand will then travel up to the axilla on the suspected side and feel for any lymphatic nodes therein. It must always be remembered that while nodes which are palpable in such cases are of importance as a confirmatory point, the fact that no nodes can be felt does not mean that they are not the seat of secondary malignant deposit. The actual amount of secondary new growth in them may be so small as not to produce any noticeable enlargement, or the amount of fatty tissue which surrounds the gland so great as to mask some slight increase in size. The nodes in the axilla of each side should be compared, for those in the armpit of the sound side may be as large as on the affected side, thus indicating a possibly non-malignant enlargement in both.

If after this careful examination of the mamma any doubt exists in the mind of the examiner, the time has come when a definite exploratory incision should be carried out, leave being obtained to proceed to amputation if

necessary. It is of the utmost importance that the case should not be left, even for a few weeks, in order that signs may arise which will render the diagnosis clear. Here, as in many other conditions, a policy of "wait and see" is dangerous, and should never take the place of a policy of look and see.

With the patient lying on her back, it is always well to palpate the region of the liver, so as to be sure that there is no evidence of any abnormal enlargement of this organ due to secondary deposit. Such an increase in size only takes place at quite a late stage in the disease, but every now and again a secondary growth is discovered in the liver quite unexpectedly; hence a routine examination should always be made. Further it is desirable at this time to examine the thoracic organs from the point of view of a prolonged anæsthetic, and the urine should also be tested.

**The spread of carcinoma of the mamma.**—In its early stages an epithelial new growth of the mamma is essentially a local disease, but it does not long remain so, for it tends to become disseminated. It, like all malignant neoplasms, invades adjacent tissues by continuity, and appears in remote organs by transference of emboli through the lymph (or blood) stream. A mammary carcinoma very soon involves the lymphatic nodes into which the lymph from the breast drains, and it is in this way chiefly that its further diffusion is accounted for. The lymphatic vessels of the mammary gland are numerous and widespread. They occur not only in the breast tissue proper, but also in the intervening fat. There are in addition lymph channels in the skin overlying the mamma, and in the fascia and muscular tissue subjacent to it. The lymphatics from this wide area pass to the lymphatic glands in the axilla, in the anterior mediastinum, and in the supraclavicular region (see p. 838).

It is a knowledge of these three points—namely, that carcinoma of the breast spreads by the lymphatics, that these lymphatics are numerous and widespread, and that they drain into three sets of lymphatic nodes—which has led to the modern type of thorough operation.

No operation for mammary carcinoma can be said to be truly "radical" which does not attack the whole of the lymphatic system connected with the breast, but an operation may be "thorough" so far as it goes.

The site of the new growth has a distinct bearing upon the spread of the disease, and hence indirectly upon the prognosis of the case. As already stated, the mamma may be said to have two upper and two lower quadrants. Carcinoma is most commonly found in the upper hemisphere of the gland and in its outer quadrant, about 60 per cent. of cases showing the growth here. From this region the lymphatics pass to the axillary nodes, and chiefly to those which lie along the deeper aspect of the edge of the great pectoral muscle and along the axillary vessels. When carcinoma occurs in the inner hemisphere, whether in the upper or lower quadrant, mediastinal nodes are apt to become involved, and when the upper and inner quadrant is the seat of the new growth the supraclavicular nodes may be directly invaded.

A duct carcinoma does not so readily give rise to secondary deposits in lymphatic nodes, but in every case of a tumour of this kind it is wisest to eradicate the axillary lymphatics.

Epithelioma of the nipple also tends to produce invasion of the axillary nodes, and these should be removed in every case treated by operation.

**Paget's disease of the nipple.**—Sir James Paget described a very intractable form of eczema of the nipple, which resisted all methods of treatment, slowly progressed until the nipple and areola were completely destroyed, and was followed by malignant disease of the breast. The carcinoma in these cases is not an epithelioma of the skin of the nipple, or

Plate 16a.

CARCINOMA OF THE BREAST.

The nipple is retracted; ulceration has taken place, the ulcer showing raised and everted margins. (St. Bartholomew's Hospital Museum.)

Plate 16b.

CARCINOMA OF THE BREAST IN SECTION.

The growth has infiltrated the breast and is spreading to the pectoral muscle beneath. (St. Bartholomew's Hospital Museum.)

a columnar-celled growth in the ducts leading to it, but an ordinary spheroidal-celled carcinoma starting in the acini of the breast. The modern view of this condition is that the carcinoma of the breast is the primary lesion, and that even in its early stages, when the growth is too small to be palpated, the eczema of the nipple is a secondary change resulting from obstruction by cancer cells of the lymphatics passing from the subareolar plexus into the breast (see Section VI., p. 338).

The condition is not very uncommon, and should always be kept in mind when a case of eczema of the nipple fails to respond to treatment, or progresses in spite of it. In such a case the breast should be carefully examined for the presence of a tumour. In doubtful cases an exploration should be advised to settle the diagnosis. When this is certain, the radical operation for carcinoma should be carried out.

## Operative Treatment of Carcinoma of the Mamma.

Until such time as a better mode of treatment of carcinoma of the breast is evolved, an early and thorough removal of the mamma, the underlying lymphatic tracts, and the axillary lymphatic nodes affords the best chance of cure.

Cases of carcinoma mammæ fall under three headings in relation to operative treatment—those in which operation is obviously the right course; those in which operation clearly would be futile, for the whole of the disease could not be removed; and those in which doubt must exist as to whether operation should be undertaken or not.

In reviewing the question of operation there are some important considerations upon which the patient is often anxious to have a definite statement—namely, the danger of the operation itself, the probability of complete cure, or the prolongation of life even if a complete cure cannot be promised. The mortality directly dependent upon the operation is becoming less and less, so that with a proper procedure it certainly does not now exceed 1 per cent. Complete and permanent cure may be said to occur in at least 40 per cent. of all cases radically treated, and if the axillary nodes after microscopical examination show no secondary invasion, the percentage of cure goes up to 70. Even in those cases in which operation is followed by recurrence, life is prolonged for two or more years. Hence operative treatment can be pressed for, at least in early cases, especially where no secondary deposit has formed in the first chain of lymphatic nodes.

On the other hand, there are certain conditions which, if present, absolutely contra-indicate operation; these are extensive involvement of skin, fixation of the growth to the tissues of the chest-wall, great invasion of both axillary and supraclavicular lymphatic nodes, evidence of implication of the axillary blood-vessels or nerves, such as œdema of the hand and severe pain in the distal part of the upper limb, and undoubted secondary deposits in viscera or in bones.

Another indication against operative interference is the condition known as atrophic scirrhus; but each case has to be taken on its own merits. It must be remembered that, unless carried off by some intercurrent disease, most of these cases eventually die of deep-seated secondary deposits, that otherwise healthy old persons stand operation well, and that the chronic nature of the disease indicates the probability of complete cure. An atrophic scirrhus, therefore, in a well-preserved woman with sound viscera, should be removed in a thorough manner.

Carcinoma present simultaneously in both breasts, a condition which occurs in about 1 per cent. of cases of breast cancer, does not necessarily negative operation, but adds considerably to the uncertainty of immediate and remote success. As to the actual decision whether operation should be undertaken in such circumstances, it is best to review each gland separately, and if the surgeon considers operation justifiable for one mamma, supposing the other were not affected, and the same opinion holds good for the other side, then operation is justifiable; but unless it can be carried out on both sides with a fair chance of success, no operation should be performed. If operation is decided upon, both breasts should not be removed at the same sitting, as it is impossible to do a thorough operation on both sides simultaneously. Three weeks, or possibly a month, should intervene between the two operations.

An interesting complication is sometimes seen where pregnancy is in existence with a mammary carcinoma. The rapidity with which an epithelial neoplasm advances in the mammary tissue when the uterus contains a fœtus is well known. The liability to miscarriage as a result of a severe operation has been exaggerated. Every case, therefore, of carcinoma mammæ associated with pregnancy should be dealt with by operation unless there are other clear contra-indications to operative interference.

The rather large class of cases of mammary carcinoma in which the surgeon is doubtful as to whether operation should be performed ought to become smaller and smaller with earlier diagnosis and a more ready determination on the part of women to accept the only real chance of cure. On the whole, it is better when in doubt to operate rather than not to do so.

Operations upon the breast and its neighbouring tissues in cases of malignant disease are carried out for three purposes:—

The first is to rid the patient of the whole of the disease; this is frequently termed the *radical* operation.

The second is to remove the superficial disease so as to rid the patient of that portion of the disease which is visible; this is only *palliative*.

The third is to free the patient from so-called recurrent growths, and this again is *secondary* and *palliative*.

**The radical or thorough operation for carcinoma of the mamma.**—The cure of carcinoma by operation implies the complete removal of all the disease. This is impossible when the disease has extended beyond the limits to which the surgeon can track it. It is out of the question to excise a carcinoma of the mamma except by making incisions through healthy tissues wide of the disease, never during the operation cutting across any line of infection. Bearing these two facts and the anatomical relations of the breast in mind, it will be readily seen that a radical operation means the excision of the entire mamma and the whole of the lymphatic extensions. This involves the removal of a large area of skin overlying the mamma, all the fat, mammary and axillary, the whole of the breast tissue proper, the fascia covering the great pectoral muscle, this muscle itself, except its clavicular part, and the subjacent pectoralis minor, and all the axillary lymph nodes. Such an operation as here indicated is a large but not necessarily a severe one.

There are three chief causes of "shock" in these extensive operations—loss of blood, chilling of the exposed surfaces, and undue prolongation of the operation. With care the amount of blood lost can be reduced to a minimum, and every divided vessel should be clamped either before or immediately after its section. The exposed surfaces should be promptly covered with several thicknesses of dry sterile gauze, which, while preventing the loss of heat, will also act as an efficient styptic to the smaller vessels and diminish oozing.

No undue haste should be exercised in the operation, but celerity combined with completeness is essential. An hour should seldom be exceeded for the entire procedure.

Full details of the radical operation will be found in text-books of operative surgery, and they need not be mentioned here, but a few points in connexion with after-treatment may be emphasised:

(*a*) Drainage of the large wound by a large tube introduced through a special opening in the axillary skin is generally advisable. This tube is removed in twenty-four hours, the dressing over the thoracic part of the wound being undisturbed.

(*b*) There is some difference of opinion as to whether the arm immediately after the operation should be bandaged to the side or placed at right angles to the trunk. If the former method is adopted, the forearm being left free, there is less danger of a space being left in which exudation can collect, as the inner surface of the flaps is kept approximated to the raw surface of the chest-wall and axilla, and oozing is prevented by the pressure resulting. But the arm must be freed at the end of twenty-four hours and carefully abducted to a right angle. Such approximation of the arm to the side will not interfere with subsequent good movement, provided it is not maintained too long.

On the other hand, if the arm is placed at once at a right angle to the trunk, supported by pillows, the axillary space is apt to be kept open and a greater amount of exudation formed. Oozing of blood is also greater, and generally more pain experienced.

(*c*) The patient should be kept in bed for about a week and the sutures removed on the eighth to the tenth day.

(*d*) Some surgeons believe in the efficacy of a course of X-ray treatment subsequent to the removal of the stitches as being a preventative of so-called recurrent tumours. The applications should be of a full dose on alternate days for about three weeks, care being taken to prevent dermatitis.

(*e*) It is very desirable that the patient should be inspected by the medical attendant at least every three months for three years. By this systematic inspection recurrences can be early detected and promptly dealt with.

**Secondary œdema of the arm and forearm.**—In a certain number of cases, either without, or subsequent to, operation, the whole of the upper extremity becomes greatly swollen, there being a brawny, more or less solid, œdema of the tissues. This condition is due to the lymphatic vessels in the axilla or thorax being blocked by the extension of growth into them, or to their being obstructed by the contraction of scar tissue around them. The limb not only becomes useless, but is a source of great discomfort, hanging as a heavy, cumbersome member (see Fig. 106).

There are two ways in which this condition can be dealt with. The first is lymphangioplasty, and the second is amputation at the shoulder-joint.

Lymphangioplasty is an attempt to establish new lymph channe. subcutaneous introduction of strands of sterile floss silk from the distal affected area into the proximal normal region. Some cases have shown temporary benefit, but none have been completely or permanently relieved.

Amputation, though a drastic measure, has the great advantage of entirely relieving the sufferer of her trouble.

In the late stages of carcinoma mammæ patients die from sepsis, hæmorrhage, pleurisy, and secondary visceral deposits.

**Sarcoma of the mamma.**—Sarcoma of the mammary gland is the form of malignant growth which arises in the connective tissue. It is not nearly so common as carcinoma.

*Etiology.*—Sarcoma may appear in the mamma at almost any age, but is most common between thirty and fifty years of age. Frequently there has been a definite history of an injury, particularly a blow, inflicted upon the mamma not very many months before the onset of the disease. There s an increasing suspicion that trauma has a direct bearing upon the commencement of sarcoma.

There are two varieties of sarcoma found in connexion with the gland. The round-celled, the growth of which is very rapid and its malignancy very intense, is seen almost as frequently as the spindle-celled, in which the rate of increase is not quite so marked and the malignancy a little less. Both tend to infect the lymphatic nodes in the axilla, although not so uniformly as carcinoma, but should the skin become involved the lymphatics are always affected. There is a great tendency to the formation of cysts, and into these hæmorrhage may occur, causing very sudden enlargement of the swelling. Because of this cystic degeneration the disease was often in the past called "cystic sarcoma." The contents of these cysts vary considerably, but most of them have had blood in them, and hence the fluid is brown or chocolate-coloured. At other times the amount of blood may be so great as to overshadow any other constituent.

*Signs and symptoms.*—Sarcoma, when it attacks the mammary gland, begins as a rounded, smooth, softish tumour. The skin is not adherent; the tumour moves somewhat in the breast tissue, and the breast upon the deeper structures; and there is no enlargement of the nodes in the axilla. It is unfortunate that at this period in the history of the lesion failure to recognise its gravity occurs. Any suspicious tumour of this type should be at once submitted to exploration and, if necessary, microscopic examination. It is very rare to find more than one growth in the same mamma. One characteristic of a sarcoma is that as soon as the growth assumes fair proportions it varies in its consistency in different parts, one portion being firm, another soft, and a third definitely fluctuating. This condition is chiefly dependent upon the presence or not of cysts. The skin tends to become involved and reddened, so much so that the new growth is sometimes mistaken for an abscess, and an incision is made into it, only to reveal the actual neoplasm. Later also the lymphatic nodes are clearly infiltrated, and signs of secondary deposits are evident. These sarcomata of the breast disseminate both by the blood and the lymphatic stream. The most common sites of secondary infection are the lungs and bones of the spine. When the skin is involved it may give way with severe hæmorrhage, and sepsis supervene, rapidly bringing about the death of the patient.

The *treatment* of sarcoma of the mamma is early and thorough removal, including the pectoral muscles and the nodes in the axilla. It is very unlikely, if recurrent nodules form, that any good will result from their removal. If there is a single focus of secondary growth, the insertion of a tube of radium may cause its disappearance.

When an early sarcoma of the mamma is explored with a view to diagnosis it will be found to be a fairly well encapsuled tumour, and if its substance be cut into it will be seen to present a flesh-like, easily bleeding surface, which under the microscope shows the typical cells of sarcoma. It is probable that only in these early cases is there much if any hope of a permanent cure, but it is really helpful to the patient to lose a mass which sooner rather than later will involve the skin and fungate.

# Section XVIII.

## DISEASES OF BONE.

Bone and cartilage are the only tissues of the body which have a firm solid structure. Other tissues as they grow are able to adapt themselves to alterations in size and shape without at any rate any considerable absorption of the part already formed. This is not so in bone. In such a solid tissue, adapted by its intimate structure to withstand strain with a minimum of weight, every alteration of size necessitates a complete rearrangement of the internal architecture. Muscle, ligament and bone are the only tissues which have to bear a more or less continuous strain. Muscle is able to withstand strain because of its contractile power, but if one particular muscle has to bear a continuous strain it will prove unequal to the task and will become overstretched. Muscles carry the necessary strain because they are able to adapt themselves continually. When certain muscles become overtired the position is altered and adjusted so that others take up the work. Ligaments similarly are relieved of continuous strain by the action of muscles. No ligament, however strong, can stand a continuous strain without stretching. Bone alone of all tissues is able to bear a continuous pressure or strain without becoming deformed. This it does because it has a definite architecture and because it has the power to adapt this architecture to the strain or strains to which it is subjected. Not only during the period of growth has it this power, but throughout life. Such adaptations necessitate considerable absorption of old bone in addition to the formation of new. It thus occurs that bone is a tissue which undergoes active adaptative changes throughout life, and these changes involve complex processes, including the laying down of new lamellæ and Haversian systems as well as the absorption of the old calcified matrix. In addition the central cavities of bone are filled with marrow, a tissue of which the functions are even now but little understood, but which, there can be little doubt, include an active part in the production of certain constituent parts of the blood, so that it also is an active generating tissue throughout life. It will thus be seen that bone, in addition to being an extremely complex tissue, has a unique cellular activity. This activity has an important bearing upon the pathology of bone, helping to explain peculiarities in its reaction to inflammation, in its adaptation to injuries and deformities, and in the forms of metaplasia and new growth that occur in it. A consideration of the physiological activities of bone in adapting itself to injuries and deformities will be found in the section on fractures under *Union of Fractures* and *Transplantation of Bone*, and in the section on deformities.

### Hypertrophy of Bone.

True hypertrophy of bone means that every constituent of the bone is equally enlarged, and that this enlargement is not associated with any fundamental alteration in structure. In many so-called hypertrophies—for example, in osteitis deformans and leontiasis ossia—the bones, although abnormally large and thick, are pathologically unaltered. True hypertrophy occurs in a muscular subject as the result of increased strain. In such a hypertrophy,

in addition to a general enlargement of bone, it is usual to find that the ridges marking the attachment of muscles are more prominent than in a lighter bone.

Another example of hypertrophy occurs in the bones of a limb which shows an abnormal size throughout, the bones partaking of the hypertrophy which involves the entire limb. In acromegaly many of the bones are hypertrophied without any evident pathological change. The hypertrophy, however, affects different bones or parts of bones unequally, so that it may produce an anatomical alteration (see p. 178).

### Atrophy of Bone.

In atrophy of bone the bone tissue is diminished in thickness, the compact tissue forming a much slighter cylinder than normal and the cancellous tissue consisting of thin trabeculæ arranged in a very open network. The term "atrophy" should only be used when these changes result from some general metabolic condition and not from inflammatory or other local conditions of the bone. It is difficult even then to draw the line between a simple atrophy of the bone, between the atrophy of fragilitas ossium, which is pathologically of an exactly similar nature, and the atrophy of osteo-malacia, in which there is an alteration in its histological structure. For the causes of atrophy of bone see p. 525.

### Inflammation of Bone.

*General Pathology.*—The changes that occur in inflammation of the bone are similar to those which take place in inflammation in other tissues. Certain peculiarities, however, result from the behaviour of the cells of bone and medullary tissue as a reaction to inflammation, and also as a result of the density of bone, which effectually prevent the occurrence of effusion, or if an effusion occurs, produce complications of an important nature.

The connexion between periosteum and bone and the mode of nutrition of the bone by vessels passing from the medullary cavity and from the periosteum into the Haversian canals and cancellous spaces has also an important bearing upon the effects of inflammatory lesions of bone. It must be remembered that the actual bone substance is avascular, and that it depends for its nutrition upon the vessels which lie in the Haversian canals or other spaces between the bone trabeculæ. In an acute inflammation of the bone, as in an acute inflammation of any other part, there is a tendency to the production of an exudate from these vessels, and this exudate has no possible exit to the exterior. In such an acute inflammation there is a considerable tendency to a blocking by thrombosis of the vessels within the spaces of the bone. Possibly this thrombosis results from the actual growth of micro-organisms in the arterioles; possibly it depends upon obstruction by pressure of the exudate around them. The result of such a thrombosis may be to cut off the nutrition of the surrounding trabeculæ of bone. This bone dies, that is, undergoes necrosis, the dead portion of bone forming thereafter a "foreign body," called a sequestrum.

If the inflammation is very limited in extent, or due to infection of low virulence, the necrotic portion of bone may be small. If it is extensive, and the virulence high, a large portion of bone, amounting even to an entire shaft, may become necrotic. When a piece of bone taken from another part is grafted on to living bone, this graft becomes necrotic so far as its bone elements are concerned, although the cells of the bone spaces may remain living.

But if the graft has been introduced aseptically, it will not cause an inflammatory reaction around, with a tendency to the production of effusion and to the eventual discharge of the graft. Instead, it produces reactionary changes in the bone cells which result in its gradual absorption and replacement by new bone. Necrosis of this nature may be called "aseptic necrosis of the bone."

The reaction of living bone to a sequestrum formed by necrosis resulting from an acute septic process may be well studied in the necrosis that occurs at the end of an infected amputation stump. If the end of the bone in an amputation becomes infected, necrosis commonly occurs in a ring of bone around the cut extremity. This necrosis results partly from injury and infection of the periosteum, partly no doubt from infection invading the Haversian spaces. It is generally limited to the terminal half-inch or three-quarters of an inch of bone. At the upper margin of the dead portion the living bone becomes more vascular and the cellular elements begin to proliferate. The osteoclasts commence to eat away the bone at the point of junction of the living and dead tissues. A line of demarcation occurs in the bone formed by a process similar to the line of demarcation which occurs in gangrene of the soft parts, with the addition that actual compact bone is absorbed by the direct action of these giant cells.

The process is a slow one, but after a time, which varies with the thickness of the bone that is to be absorbed, the necrotic tissue is separated off from the living bone above, a definite loose sequestrum being formed. When this sequestrum is pulled off, the living bone will be found to be covered with a layer of granulation tissue which has grown along the line of demarcation in the process of separation.

The periosteum is another important tissue in acute inflammation of the bone. The fibrous periosteum is generally considered to have the function of acting as a limited membrane which carries the blood supply to many of the Haversian spaces of the compact tissue. Underlying this fibrous periosteum is a loose alveolar layer, through which the periosteum can be separated from the bone with comparative ease. On the deep surface of the loose tissue is a layer of osteoblasts. These are abundant in young subjects whilst growth is occurring, but scanty in adults.

If an acute septic inflammation extends to the periosteum, an effusion occurs beneath this membrane, raising it from the bone. This effusion rapidly becomes purulent. The immediate effect of such stripping is to cut off the blood supply of the superficial part of the compact tissue, which undergoes necrosis. Necrosis of large sections of bone occurs chiefly when the periosteum is stripped by a purulent effusion in this manner. The osteoblastic layer undergoes proliferation immediately the periosteum becomes inflamed, and this layer is raised with the periosteum over the effusion. It thus comes about that the periosteum as raised by an effusion carries with it an osteogenetic layer capable of re-forming fresh bone.

An acute infection of the bone may then affect the periosteum (*periostitis*), the tissue of the bone itself (*osteitis*), and the medullary cavity (*osteomyelitis*). Pus may be formed beneath the periosteum, in the interior of the Haversian canals and cancellous spaces, and in the medullary cavity, and the result may be the formation of sequestra from the necrosis of larger or smaller portions of bone substance. If pus forms beneath the periosteum, it may secure an exit by gradually extending to the surface or through a surgical incision. Pus formed in the interior of the bone or in the medulla is less likely to secure a spontaneous exit.

In some cases the infection first attacks the cancellous bone close to the epiphyseal cartilage in a growing bone. This region is rendered especially liable to infection by the fact that its arteries form terminal loops which are easily plugged with pyæmic plugs. The bone at this spot is light and thin, and easily destroyed by a comparatively slight inflammatory action. Consequently separation of the epiphysis, bearing with it the epiphyseal plate of cartilage, from the diaphysis is a not unusual result.

Infection of this region (*epiphysitis*) may occur as a primary condition, or may be a part of a general infection of the periosteum, bone, and medulla.

The periosteum, stripped by an inflammatory exudate, soon commences to form new bone upon its deep surface. The bone thus formed is generally rough and irregular, but if the periosteum has been completely stripped, it tends to ensheathe the whole of the necrotic area, extending on to healthy bone beyond it, with which it is continuous. The sheath of new bone thus formed is termed the *involucrum*. This sheath is interrupted at certain points corresponding to the points at which the pus has gained its exit, and at which consequently the periosteal covering was incomplete. These points are termed *cloacæ*.

Infection of bone results in the above pathological changes when it is due to one of the ordinary micro-organisms of acute infections, such as the staphylococcus aureus and the streptococcus pyogenes.

In certain inflammations of bone the changes are of a much more chronic nature, and necrosis does not occur. Such a chronic osteitis may take one or other of two forms; one is termed a *rarefying osteitis*, the other a *sclerosing osteitis*. In these forms of inflammation the peculiarities depend upon the effective part taken by the osteoclasts and osteoblasts.

In rarefying osteitis absorption of bone takes place at a greater pace than does the formation of new bone, so that the Haversian canals and cancellous spaces are enlarged. The bone of the trabeculæ is thinner than normal, and becomes irregularly arranged.

In sclerosing osteitis the changes are of the opposite character: new bone is formed more rapidly than it is absorbed, with the result that the bone is thicker, heavier, and denser. A combination of the two processes is not at all unusual, a considerable formation of new bone co-existing with rapid absorption, so that, although the bone appears more massive than is normal, it is found on section that the Haversian canals are enlarged and the bone generally of a more open texture and more vascular.

Chronic osteitis of one or other of these types may occur in septic infections during the subacute or chronic periods. In these cases the contents of the medullary cavity and other spaces in the bone may be partly of the nature of proliferating marrow, partly of the nature of granulation tissue, and partly of the nature of new inflammatory fibrous tissue. In other cases these forms of chronic osteitis are due to some special specific inflammation, such as tuberculosis or syphilis; the contents of the bone spaces may then consist, in part at least, of that form of chronic granuloma which is peculiar to the infection; definite tubercles, with or without caseation, are found in tuberculous disease, gummatous tissue, or chronic inflammatory tissue, with much formation of new fibrous tissue and with arteries showing characteristic arterial changes, in syphilitic infection.

In other cases a chronic inflammation of the bone results from an aseptic cause. For example, in an injury to an exposed bone a chronic periostitis with thickening may occur without any infection having taken place.

The changes in the bones in osteitis deformans are of the nature of a chronic osteitis, with a combination of sclerosis and rarefaction, and, finally, bone which underlies an inflamed area, but which is not itself infected, may show the changes of a chronic osteitis, as, for example, in the thickening sometimes seen in the front of the tibia beneath a chronic ulcer of the shin.

**Clinical forms of inflammatory disease of the bones.** I. **Acute simple periostitis.**—An injury damages the periosteum, perhaps producing a hæmorrhage beneath it, and is followed by a painful swelling. After a short interval an X-ray may show that there is deposit of new subperiosteal bone. In many cases the X-ray will also show that there was really a fissure into the bone beneath the periosteum, produced by the original injury.

*Treatment* is by rest and the application of mild counter-irritants.

II. **Acute periostitis due to specific organisms.** — Occasionally in the course of an infection with some particular micro-organism—for example, in typhoid fever—a subperiosteal abscess of bone arises. A swelling appears over the shaft of the long bone with evidence of inflammation, and on incision pus is evacuated. The micro-organism which is the cause of the infection can be cultivated from the pus.

Incision down to the bone and evacuation of pus is the correct treatment, but if the stripping of the periosteum has produced necrosis of the bone beneath it, the wound will not heal until time has elapsed sufficient to allow the separation and extrusion of the sequestrum formed.

Fig. 329.—Photograph of a dry preparation of a tibia attacked by osteomyelitis in the course of typhoid fever. Typhoid bacilli were found in the pus. On the surface is seen a depression, marking the site of a subperiosteal abscess, which communicated with the abscess cavity in the centre of the tibia by a small hole through which a bristle has been passed.

III. **Acute infective osteo-periostitis or acute necrosis.**—In this condition the bone is infected through the blood-stream without any direct communication from the exterior. The disease is most common in children, although it may occur in adults. Any part of the bone may be affected. Thus the disease may be an acute periostitis with stripping of periosteum and necrosis of part of the compact tissue, varying from a minute fragment up to the whole of the shaft, or the infection may start at the epiphyseal end, so that the first incident is an acute inflammatory swelling around the epiphyseal cartilage and a separation of this from the diaphysis (acute epiphysitis), or the first infection may occur in the medulla, so that the local signs are obscure (acute osteomyelitis).

The infective agent is nearly always the staphylococcus aureus, although the streptococcus pyogenes may sometimes be found.

The pathological changes are those already described on page 803.

The onset of the disease is usually sudden, with a high temperature and perhaps a rigor, the patient being obviously ill and showing general evidence of septic infection. The local symptoms may be only very slight, or may be severe.

If a considerable area of periosteum is affected over an exposed part of the bone, there will be much swelling, redness, heat, and other inflammatory signs. If, on the other hand, only a limited area of periosteum is affected, and this in some deep-seated part, such as the neck of the femur, the iliac fossa, or some other part of the pelvis, there will be no local evidence other than acute pain. If the medulla of the bone is affected, the pain is very severe, but in the early stages there is no other local evidence of infection.

As the disease is a blood infection and as the pus is usually confined under pressure either beneath the periosteum or in the medulla of the bone, an early diagnosis and incision for evacuation of pus is vitally important.

Difficulty may arise in diagnosing the condition from an acute cellulitis, acute rheumatism, or from other infections peculiar to the particular area affected. Thus in osteomyelitis of the ilium confusion with appendicitis has arisen. The onset with a high temperature and rigors, the presence of a continued elevation of temperature up to 103° or 104°, with flushed cheeks, frequent pulse, furring of the tongue, and other symptoms of acute septic infection, should arouse the suspicion that a localised pain or tenderness over a bone is caused by an acute infection at that spot. A leucocyte count will assist, as in acute periostitis or osteomyelitis, as in all infections with staphylococcus aureus, a considerable leucocytosis will be present.

In acute rheumatism the joint is the seat of the swelling and pain rather than the bone in its neighbourhood, and the leucocyte count is not, as a rule, high. If there is any doubt at all as to the existence of an acute infection of the bone, an exploratory incision should be made, for delay, if such an infection is present, both increases the liability to a general pyæmia and also leads to necrosis of a much larger extent of bone.

*Treatment.*—An early and free incision for the evacuation of pus is necessary both to save the patient's life and to prevent excessive necrosis of the bone. The first incision should be down to and through the periosteum, in order that any pus lying beneath this membrane may be evacuated. The whole of the stripped area of periosteum should be opened up and explored. If no pus is found beneath the periosteum and if this membrane is hyperæmic and swollen, a linear incision, a half-inch wide, should be cut through the compact bone into the medulla, in order that any pus in the medullary cavity may be evacuated. At this first operation the only object is to open a septic area sufficiently to allow drainage, and secondary operations for the removal of sequestra, etc., will almost certainly be necessary.

When the epiphyseal region has been infected, a secondary septic arthritis is not very uncommon. In severe cases in which there is very extensive necrosis, separation of the epiphyses, and particularly septic arthritis, an immediate amputation of the limb may be considered advisable.

The separation of the sequestra formed as a result of the necrosis takes place gradually by the process already described. The condition then becomes one of chronic osteomyelitis, with cavities in the bone, cloacæ, and sequestra. The treatment of this condition will be described later.

A more chronic form of infective periostitis or osteomyelitis sometimes

Plate 17.

Skiagram showing chronic periostitis of the lower end of the femur. The diagnosis of the swelling lay between periostitis and a new growth. (Taken by Dr. Hugh Walsham.)

occurs, the infecting agent being an organism of lower virulence, such as the staphylococcus pyogenes albus. The onset is less acute, the local symptoms are more prominent, and the general symptoms of infection less so, than in the acute form. Thus in a chronic osteomyelitis due to a blood infection there will be a painful thickening of one of the long bones with irregular rise of temperature, but without marked general symptoms of infection. An X-ray photograph may show a thickening of the whole bone by deposit of new subperiosteal tissue, the compact tissue of the shaft being perhaps of a somewhat more open texture than is normal.

A leucocyte count shows a leucocytosis of perhaps 20,000 to 30,000 as evidence of the presence of a septic infection.

Incision into the medulla of the bone discloses the fact that it is filled with purulent contents.

A special form of acute infection of the epiphyseal regions occurs in young children, often within the first few months of life. An acute inflammatory swelling occurs in the region of one of the larger joints, with general symptoms of infection which are rather less severe than in the case of acute osteomyelitis or epiphysitis of older children.

Incision into the abscess that has formed discloses the fact that the joint is filled with pus, and that this abscess communicates with the diaphysis of the bone close to the epiphyseal line. In some cases the epiphysis may be separated, and in the case of the femur it is not unusual to find the head of the bone loose in the abscess cavity (*acute epiphysitis of infancy*).

IV. **Periostitis and osteomyelitis produced by infection from without.**—Infection of any wound which involves the periosteum or the bone will produce an acute infective periostitis, osteitis, or osteomyelitis. For example, in a compound fracture which is infected or in a septic amputation stump this complication arises. The pathological changes which take place are the same as those already described, and effusion, suppuration, necrosis, and formation of new bone may all occur, as in acute infections which are brought by the blood-stream.

The chief differences depend upon the fact that there is from the first a potential exit for the pus, so that the liability to extensive effusion and resulting necrosis is less, and upon the fact that, in cases of compound fracture, the periosteum is often much torn, so that the shaft of new periosteal bone formed from it is less complete.

In compound fractures the bone is often splintered, so that portions are attached only by periosteum or may even be completely detached and lie loose between the ends of the main fragments. If infection occurs, fragments which are quite loose will certainly become necrotic and form sequestra, but other fragments which possess a periosteal covering do not necessarily die—at least, in their entirety. In infected compound fractures sequestra are usually found, but they are formed chiefly as the result of stripping of the periosteum by the extension of the pus, and necrosis of the bone beneath them.

V. **Chronic osteomyelitis.**—Whatever the origin of a septic infection of the shaft of the bone, whether it has resulted from an acute infection through the blood-stream, or from a similar infection of more chronic nature, or by extension from without, if the patient survive and the limb be retained, a condition ultimately arises in which sinuses lead down to the bone, passing through cloacæ in the new periosteal bone formed and entering cavities in which sequestra lie. This condition of chronic osteomyelitis with cavities and sequestra is a common one, which presents very great difficulties in treatment, and which is also a potential source of danger to the patient,

inasmuch as a change of the local conditions or of the general resistance of the patient may give rise to a renewed spread of sepsis with additional necrosis, and possibly even to a general septic infection. The cure by surgical means of a chronic osteomyelitis is therefore important, and this cure must depend upon a clear understanding of the pathological changes that are present.

FIG. 330.—Chronic osteomyelitis of the tibia with new periosteal bone formation and central necrosis. *a*, Sequestrum in a cloaca. (St. Bartholomew's Hospital Museum.)

Just as the phenomena of acute inflammation in bone differ from those of acute inflammation in other tissues because of certain individual peculiarities of the bone, so the method of healing of a chronic inflammatory lesion of the bone is unlike that of the healing of soft tissues.

When an abscess occurs in soft parts, due, for example, to the presence of an infective foreign body, the pus is evacuated by spontaneous bursting of the abscess or by a surgical incision, the foreign body is extruded or extracted, the walls of the abscess fall together, the granulation tissue lining them adheres, and the cavity is thus obliterated. If for some reason, however, the foreign body is unable to find an exit of sufficient size, a chronic sinus leading down to it remains until the foreign body is removed. If chronic suppuration has lasted for a considerable time, and the walls of the abscess have thickened and become rigid, it may be impossible for them to fall in and close the cavity. Thus a sinus in the soft parts may become chronic for two reasons: first, the continued presence of a foreign body, and secondly, the rigidity of its walls. In a chronic sinus leading into a cavity in a bone in which a sequestrum lies both of these causes of delay to healing are present. The opening through a cloaca into the sequestral cavity is usually too small to permit of the exit of the sequestrum, and even after the sequestrum has been removed the cavity left is surrounded by rigid bone, so that a falling-in of its walls and resulting obliteration cannot take place. Such a cavity in the bone can only be filled either by the gradual production of new tissue or by the insertion into it of some other tissue by surgical means.

It is well known that an aseptic cavity in the bone, such as is produced by opening and curetting a simple cyst or a small tuberculous abscess, may be left to fill up by natural means with tissue produced by the adjacent marrow of the bone. New bone tissue, marrow and fibrous tissue can thus grow and fill a cavity of considerable size.

In a cavity which is infected with septic micro-organisms the condition is very different. The lining of the cavity consists of granulation tissue, which may slowly grow and become organised into

fibrous tissue or partly into bone. But such organised inflammatory tissue tends gradually to contract and to form a very dense layer ("pyogenic membrane"), which is comparatively avascular. The fact that the cavity is surrounded after a time with such a dense layer prevents the indefinite ingrowth into it of new tissue, so that in many cases the entire cavity fails to fill, and a central space, lined with granulation tissue and communicating with the exterior through the sinus and cloaca, remains.

There are thus two main points to be considered in the treatment of a chronic osteomyelitis of bone: first, the existence of sequestra which require removal, and second, the possible occurrence of a cavity which fails to close even after the sequestra which lie in it have been removed.

Before undertaking surgical treatment of a chronic osteomyelitis it is necessary to determine what sequestra are present and whether these are loose or not. Examination with probes inserted into any sinuses present may assist in the diagnosis of the presence of definite sequestra which are mobile.

The feel of a sequestrum under the probe is characteristic. The probe is felt to strike bare bone, which is often rough, whereas in other parts of the sinus it meets only bone which is covered with granulation tissue. The fact that a sequestrum is separated may be detected with the probe, but it is difficult to be certain upon this point. X-ray examination is valuable. If possible the bone should be X-rayed in two planes at right angles to each other, or a stereoscopic X-ray may be taken. The insertion of probes into the sinuses at the time the X-ray is taken may assist considerably. In some cases it is difficult to follow out the track of a sinus with a probe, and it may be advisable to inject some opaque substance which will fill the sinus and mark out the whole of the septic tracks in the X-ray photograph. An emulsion of bismuth subnitrate in water, to which a little gum is added, is the best substance to use for this investigation. It should be injected into the sinus with a syringe under considerable pressure immediately before the plate is taken, any bismuth remaining upon the skin being carefully wiped off.

By examination with the probe and with the X-ray photograph an effort should be made to picture the condition of the bone at the site of the disease, so that the extent of the sinuses and cavities and the position of sequestra may be located. However carefully this examination is made, it is seldom possible to be quite certain of the number of sequestra, or whether these are completely detached or not. It is essential before operating to make sure that the sequestra are detached, because in operating through a septic field, if sequestra have to be cut away from the bone, there is a considerable liability to the formation of fresh sequestra at the site chiselled through.

It is usual to assume the separation of sequestra by considering the time that has elapsed since the necrosis occurred. In most bones in a young adult two or three months are necessary to allow of the separation of sequestra. In some large bones this time is insufficient. For example, sequestra of the shaft of the femur take three or four months to separate, those of the shaft of the tibia may take up to six months, and sequestra of the surface of the skull may take still longer.

*Treatment* of chronic osteomyelitis depends upon the stage to which the disease has progressed. Before the sequestra have had time to separate treatment should be confined to rest of the limb upon a splint, incision down to the bone whenever pus requires evacuation, and daily dressings, which may be carried out either with aseptic gauze or with an antiseptic.

During this stage means may be taken to diminish the virulence of the

sepsis. Thus in large abscesses and tracks irrigation through Carrel's tubes, or daily irrigation of the wound with such an antiseptic as eusol, may assist. The patient must be watched all the time for evidence of fresh infection as given by the occurrence of general symptoms, such as a rise of temperature, or of local symptoms such as swelling and other inflammatory signs in some new situation.

When the time has come for the removal of sequestra, a thorough operation should be performed. In certain cases, more particularly in the smaller bones, it may appear that only one or two sequestra are present, and that these can be easily reached. If this is thought to be the case, a simple opening

FIG. 331.—Chronic abscess in end of tibia. The so-called pyogenic membrane is well seen. (St. Bartholomew's Hospital Museum.)

FIG. 332.—Central necrosis of femur with periostitis. (St. Bartholomew's Hospital Museum.)

up of the sinuses, freeing and removing the sequestra, may be sufficient. In larger bones, however, an exploration should be made by a free incision by whatever route will expose the bone best. The whole of the infected area of bone should be examined, cavities and tracks opened up by chiselling away overlying bone, and every effort made to remove all the sequestra that are present. If it then appears that a cavity is left which may not fill, because there is no soft tissue which can fall into it, the walls of this cavity should be chiselled away and bevelled down as much as possible without unduly weakening the shaft of the bone. Scar tissue should be freely removed, and, if necessary, a flap cut from some neighbouring muscle must be freed, so that it can fall into and fill the cavity. If all sequestra, scar tissue and granulation

tissue have been thoroughly removed, it may be possible after treating the wound with "Bipp" to suture it, leaving a small drainage tube. If, however, there is any doubt as to the removal of the whole of the septic tissue, it is better to leave the wound open, packing it with some antiseptic and allowing it to granulate until it is seen that the bone has completely granulated over, and that no further dead tissue remains. Gauze soaked in a mixture of paraffin, flavine and methylated spirit is the best material for this purpose. When granulations cover the whole of the surface of the bone, the wound may be closed by secondary suture.

VI. **Central abscess and central necrosis.**—Occasionally in young people a central abscess of bone, due to a chronic septic infection, arises spontaneously (Brodie's abscess). A child complains of pain most often in the end of a diaphysis, not far from the epiphyseal line. Thickening of the bone is discovered at this point, and an X-ray photograph shows the existence of a central cavity with periosteal thickening of the bone around (Fig. 331). In older people a similar condition may occur with perhaps a sequestrum showing in the central abscess.

Such a case may be mistaken for a new growth of the bone unless it is examined radiographically.

The treatment is by incision, curetting of the abscess and removal of the sequestrum, bevelling down the margin of the track into the abscess, and, if the pus obtained demonstrates that streptococci or staphylococci are present, the filling of the cavity left with a small flap of muscle.

Examination of the pus by films is necessary, because a similar abscess may occur in young people as the result of a tuberculous infection. In the latter case a simple opening and curetting of the abscess may be sufficient, immediate closure of the wound being advisable.

FIG. 333.—Chronic periostitis of tibia. *a*, Thickened periosteum. (St. Bartholomew's Hospital Museum.)

VII. **Tuberculous disease of bone.**—Tuberculous disease may affect any part of the bone, but most often it affects the cancellous tissue either near the ends of the long bones or in the smaller bones, such as the bones of the tarsus and carpus. The infection is probably hæmatogenous in origin. Children are more commonly affected than adults, but the infection may start at any age from infancy to old age.

In a tuberculous osteitis the first change consists in the development of ordinary tubercles in the medullary tissue which fills the spaces of cancellous bone. The tubercles are histologically exactly like those occurring in other tissues. Around them the bone undergoes lacunar absorption, the bone tissue being destroyed by osteoclasts, as in other forms of rarefying osteitis. The tuberculous tissue thus slowly extends in a rarefied area in the bone. At the same time caseation takes place, so that a central necrotic area appears.

If the process has gone on slowly, the bone is absorbed before necrosis occurs. If, however, it is more rapid, necrotic bone may be found in the caseous material.

In a tuberculous infection which has not been secondarily infected with pyogenic micro-organisms the necrotic bone is small in amount; the sequestra are never large, and always consist of soft rarefied bone, with yellow caseous material lying in the cancellous spaces. The sequestrum of a tuberculous infection thus differs very considerably from that which results from an acute septic infection.

FIG. 334.—Tuberculous dactylitis in a young adult. Photograph of the fingers showing tuberculous ulcers following disease of the phalanges.

In some cases the tuberculous infection may extend widely through an area of cancellous bone, so that the whole of the bone is rarefied and softened (*diffuse tuberculous osteomyelitis*).

In others the infected patch is circumscribed; the contents soften, break down, and form an abscess which becomes limited by a reactive inflammation around, resulting in a slight degree of sclerosis (*localised tuberculous disease*).

In others, again, a similar central abscess may form, but may contain a central tuberculous sequestrum (*central tuberculous necrosis*).

Around a bone which is infected with tubercle there may, or may not, be a secondary periostitis, with the growth of new subperiosteal bone. As a

rule the presence of periosteal thickening around the central abscess or central necrosis is evidence that the infection is due to one of the septic micro-organisms, but this is not invariably true, as a periostitis may exist around a tuberculous focus.

Tuberculous disease commencing primarily in one of the bones gives rise to indefinite symptoms until the bone has become considerably enlarged or until the tuberculous tissue has extended to its surface and burst into the tissues around the bone.

Whilst the disease is confined to the interior of the bone diagnosis can only

FIG. 335.—An X-ray photograph of the same hand as that depicted in Fig. 334. The first phalanges of the middle and little fingers show a central tuberculous osteomyelitis with periosteal thickening.

be made by the discovery in an X-ray photograph of either a diffuse area of rarefaction or of a localised abscess, attention having been called to the region of the disease by the existence of localised pain with or without an enlargement of the bone itself.

If the disease is discovered and promptly treated at this stage, a further extension should be avoided. If, however, it is allowed to extend, the tuberculous process may burst through either into the tissue around the bone, forming an intermuscular or intramuscular abscess, which eventually reaches the surface, or it may burst through the end of the bone into a joint in which it sets up an acute tuberculous arthritis.

The diagnosis that a localised focus in a bone as seen in an X-ray is due to tuberculous disease may not be simple. Abscess or central necrosis due to staphylococcus aureus or albus, gummatous disease, central cysts, and central new growths are the chief conditions which may require differentiation (see *Differential Diagnosis of Endosteal Tumours*).

The *treatment* of endosteal tuberculosis may be carried out upon two distinct lines.

In the first place, in many cases of diffuse tuberculous osteomyelitis or of localised tubercle complete rest of the affected part of the limb, including immobilisation of the neighbouring joints in plaster of Paris or in a splint, may be sufficient to cause arrest of the disease with ultimate enclosure by

FIG. 336.—Chronic osteomyelitis. X-ray photograph of the lower end of the radius enlarged by chronic central tuberculous osteomyelitis. Note the overgrowth of the bone in length.

new sclerotic bone, so that the focus of tubercle gradually becomes fibrotic and calcified, as in tuberculous disease in other situations. If this expectant treatment is carried out, a radiographic examination should be made at intervals, so that the extent of the tuberculous focus may be watched, any increase in size being specially noted and the bone around the tuberculous disease being at the same time watched to note whether it is undergoing sclerosis. If the cavity ceases to enlarge and the bone around is sclerosing, the expectant treatment may be continued until a final cure has resulted. If, however, there is any indication that the tuberculous area is becoming larger, particularly if it is extending to the neighbourhood of a joint, it is better not to wait, but to adopt a more radical line of treatment.

The bone should then be exposed by whatever route is found simplest, an

opening of sufficient size chiselled into the tuberculous cavity, and the whole of the latter thoroughly curetted out until healthy bone is exposed on all sides. The cavity thus left in the bone should be aseptic: it can be safely allowed to fill up by natural processes, the wound being sutured completely.

Following such a radical operation, the limb should be rested for a period of six months, the neighbouring joints being immobilised.

In diffuse tuberculous osteomyelitis affecting a considerable part of the extremity of the long bone Stiles advocates subperiosteal resection of the whole of the affected portion of the shaft down to the epiphyseal line, the limb being carefully supported upon a splint with extension upon its distal fragment, until reconstruction of the shaft has taken place by growth from the sub-periosteal osteoblasts.

VIII. **Syphilitic disease of bone: early periostitis.**—During the secondary stage pain may be felt in various bones, due to a subacute periostitis. Tender swellings may occur, most often on exposed surfaces, such as the tibia, clavicles, sternum, ribs or skull. These inflammatory swellings disappear either spontaneously or under ordinary treatment.

**Late periostitis and osteitis.**—During the tertiary stage a chronic inflammation of the periosteum or of the whole of the bone may occur. If the periosteum only is affected, a hard swelling appears, usually on an exposed surface of a long bone. This swelling is not particularly painful, is of bony hardness, and an X-ray photograph shows that there is a deposit of new subperiosteal bone and possibly a thickening and sclerosis of the shaft of the bone beneath.

**Gummatous disease of bones.**—Gummata may occur in any of the bones. They are perhaps particularly common upon the skull. The pathological changes are those of gummata in other tissues, a chronic inflammatory swelling arising in the bone and periosteum. In the central portion of the gumma the bone undergoes rarefaction and absorption and is replaced by syphilitic granulation tissue, showing characteristic changes in the arteries. This inflammatory tissue undergoes necrosis, so that a softened area results. Around the margins of the gumma the bone undergoes sclerosis and a moderate degree of thickening.

FIG. 337.—Syphilitic periostitis of tibia and fibula. (St. Bartholomew's Hospital Museum.)

Thus an unbroken gumma of a bone shows itself as an inflammatory swelling, perhaps red and shiny on the surface, with a central softened area and a hard margin. Such a swelling is sometimes called a *soft node*, in contradistinction to the sclerosing periostitis which is termed a *hard node*.

It is uncertain whether necrosis of portions of the bone with the formation of sequestra can arise as a result of gummatous disease without the super-

vention of septic infection. As a rule, if a gumma is left untreated, it tends to burst, discharging a thin, glairy fluid and becoming secondarily infected with the micro-organisms of sepsis. Necrosis of portions of the bone around the gumma will then almost certainly occur.

The treatment of gummatous conditions of the bone is that of other forms of tertiary syphilis. Operative interference is only called for when secondary infection has occurred and necrosis of the bone results. It may then be necessary to treat the condition as if it were an ordinary case of chronic osteomyelitis. At the present time gummatous disease of the bone is a very rare condition, because it is only likely to occur in cases in which early treatment has been neglected.

Fig. 338.—Congenital syphilitic osteomyelitis of the tibia. (St. Bartholomew's Hospital Museum.)

**Bony lesions of inherited syphilis.**—The pathological changes which occur in the bones in congenital syphilis are the same as those in acquired disease. There are, however, certain special clinical forms which are important.

Syphilitic epiphysitis occurs in infants often within the first year of life. It is characterised by the occurrence of a swelling of the epiphyseal ends of the bones, several bones being as a rule affected. The swelling is found to involve the end of the shaft and the region of the epiphyseal line, and in some cases the epiphysis may be felt to be separated. An X-ray examination shows that there is a considerable deposit of new periosteal bone around the end of the shaft.

Clinically the condition may be mistaken for rickets, but it can be distinguished from this disease by noting that the swelling extends further up the shaft and by the appearances in the X-ray.

A chronic osteitis of the tibia and sometimes of other bones occurs in children between the ages of seven to ten and eighteen to twenty. The tibiæ undergo a slow progressive thickening, which is most marked upon the subcutaneous surface. The whole bone gradually becomes bowed forwards, the upper half of the shaft being often more curved than the lower half. The bone may be elongated and very greatly curved and thickened; because the curvature resembles that of the old-fashioned sabre, the condition is sometimes termed *tibia en lame de sabre*.

An X-ray photograph shows that the front of the tibia is affected almost exclusively, the compact tissue at the back appearing normal, whereas that in front is two or three times its natural thickness and is less dense than normal, the Haversian canals showing up obviously in the photograph. The curvature of the bone must be ascribed to this fact, that the chronic inflammation affects the anterior surface, producing overgrowth in length. As the posterior surface grows at its normal pace, there is a resultant forward bowing of the bone.

It is sometimes stated that this curvature of the bone is due to overgrowth

of the tibia in length, whilst the fibula grows at the natural pace, the latter bone tying together the ends of the tibia, and producing the curvature. This explanation will not suffice, for in other cases in which the fibula ceases to grow its ends become separated from their normal attachments to the tibia, which continues to grow in a straight line.

IX. **Osteitis deformans.** Osteitis deformans is a chronic inflammatory disease of the bones with very characteristic symptoms, which was first accurately described by Sir James Paget in 1876, and is often known by the name of Paget's disease. It affects men more than women, and commences as a rule between the ages of forty-five and fifty. It may, however, arise, as in one of Paget's cases, as early as twenty-eight, or it may begin in extreme old age.

The onset is very insidious, so that it is difficult to date it exactly. As a rule the patients first complain of chronic pain in some of the long bones, or of a gradual bending of one or more bones. In a typical case in which many bones are involved, the long bones are thickened and curved, the curvatures in the main representing an increase in the normal curves of the affected bones. During the progress of the disease the affected regions may be hot, and may show other evidences of inflammation, such as œdema, redness and dilatation of the superficial vessels. The distribution of the disease in the skeleton is not regular: in some cases the entire skeleton may be affected; in others the disease may be localised to one bone. Between these extremes all grades may be found.

The tibiæ nearly always show the characteristic signs, being thickened and bowed forwards and outwards. The femora, which bow outwards, the skull, which is thickened, and the spine, which becomes kyphotic or sclerotic and rigid, are the next most commonly affected bones.

The clavicles and the rest of the long bones are often involved in the disease, the pelvis and scapulæ seldom; the lower jaw, sternum and small bones of the hands and feet nearly always escape; the bones of the face other than the lower jaw are practically never affected.

In the skull the calvarium increases immensely in thickness, so that there is evident enlargement of the head, with a filling up of the temporal fossæ and sometimes irregularity of the surface. A progressive increase in size of the head is a characteristic symptom of the disease. The compact tissue of the skull is greatly increased in thickness, but at the same time it is diminished in density, so that the surface is pitted all over with the openings of enlarged Haversian canals, and a section of the bone shows that these canals are of a size sufficient to render them easily visible to the naked eye. This thickening of the compact tissue, with a co-existing osteoporosis, is the characteristic change of the disease. It is shown in all the affected bones, which thus have their layers of compact tissue thickened till they are perhaps two or three times the normal size, but at the same time rendered more porous and softer, thus allowing the deformities to arise.

In the vertebræ it is not uncommon to find outgrowths of bone from the anterior surface of the bodies which connect the individual vertebræ together and lock them in the same way as do the similar processes in spondylitis deformans. The thorax is generally barrel-shaped or flattened laterally, and the costo-vertebral joints lose a certain portion of their mobility. The ribs may be porous and perhaps rough on the surface. There is usually a considerable degree of kyphosis and sometimes a slight lateral curvature in addition.

Whatever the age of the patient, there are practically always atheromatous

changes in the vessels. This is so striking that it seems clear that there is some connexion between arterial degeneration and Paget's disease. Probably both conditions result from a common cause (see Plate 18). Other associated conditions are chronic bronchitis, possibly due to a diminution of the chest movements, and certain changes in the central nervous system,

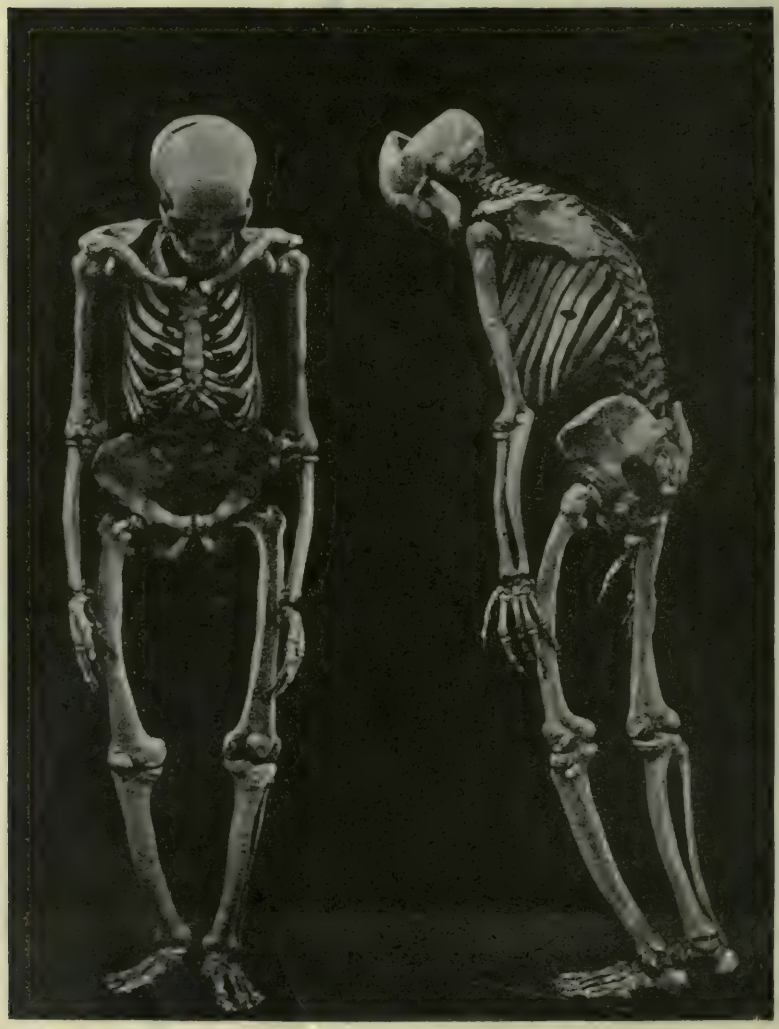


Fig. 339.—Photographs of a skeleton of one of Sir James Paget's cases in the Museum of the Royal College of Surgeons. (Copied from his paper in the *Illustrated Medical News*, 1888 and 1889.)

of which loss of vision, deafness, and senile mental decay are the most frequent; various paralyses have also been found. All these nerve changes have been carefully investigated; they are probably due to the vascular condition.

The deformities of osteitis deformans are so characteristic when the disease is fully developed that a mistake in diagnosis is scarcely possible. The

Plate 18.

Skiagram showing osteitis deformans of the tibia and calcareous vessels. (Finzi.)

Plate 19.

Skiagram of a pedunculated exostosis springing from the adductor tubercle of the femur. (Taken by Dr. Hugh Walsham.)

attitude and curvature of the bones are only an exaggeration of those normally found in old people, and one possible error is to diagnose osteitis deformans in a patient who is suffering solely from old age. In the early stage of the disease, before much deformity has arisen, diagnosis is not so simple. Persistent pain in some of the long bones, particularly in the tibia, commencing curvature of the bones, and progressive enlargement of the head are the usual early symptoms. The X-ray appearances of the bones affected are very characteristic: they show a general enlargement of the compact tissue, not a simple new periosteal deposit; but this compact tissue is less dense than the normal, the longitudinally disposed Haversian canals being clearly seen in a good negative. The only condition which may give similar appearances is a chronic syphilitic osteitis; from this a Wassermann reaction will settle the diagnosis.

The pathological processes in the bones were described by Paget and Butlin in their original cases, and, in spite of the numerous subsequent investigations, little has been added to their observations. The changes are as follows: the bone, though increased in thickness, is softer than usual; it is very porous, the Haversian canals being of large size. The actual lamellæ of the bone are irregularly arranged, but natural in appearance and fully calcified. Microscopically the walls of the medullary spaces are found in places to be in a process of absorption by osteoclasts lying in Howship's lacunæ; in these places, particularly under the periosteum, new bone is found in the process of being deposited; in fact, the whole condition consists of absorption of bone in one place and formation of new bone in another. These appearances were described by Butlin, and have been confirmed since by all observers. There can be little doubt that the condition is a chronic inflammation, but the cause of the inflammation is unknown. Our present knowledge seems to indicate a chemical poison of uncertain nature.

A considerable proportion of cases of Paget's disease have ultimately died as the result of a malignant growth, and out of thirty-four cases followed to a fatal termination thirteen suffered from malignant disease; of these in nine there was a primary sarcoma of the bone. It is probable that the association is that of a sarcoma arising in a tissue which is already affected by a chronic inflammatory process.

## New Growths of Bone.

The new growths affecting the bones are—first, those formed of tissue normally present in the bones, namely, osteomata, chondromata, and fibromata; second, those due to a metaplastic transformation of some of the constituents of bone, namely, myelomatous and fibrocystic conditions; third, malignant new growths occurring primarily in the bone, sarcoma, and very rarely endothelioma; and fourth, secondary deposits of malignant growth arising primarily elsewhere.

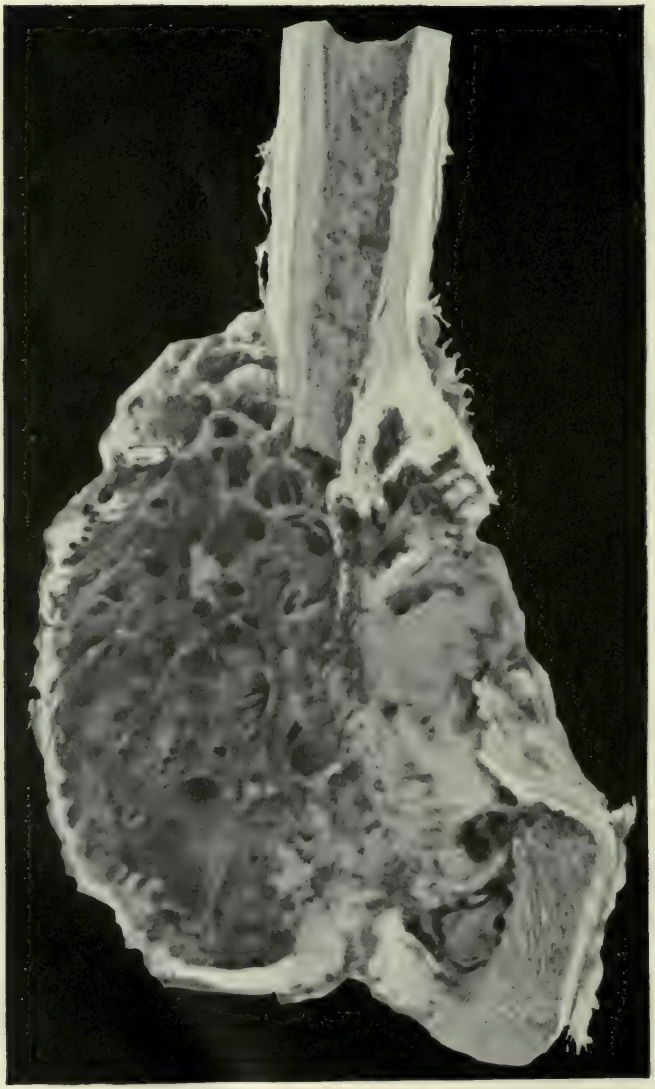
**Osteomata.** Osteomata may form tumours which project from the surfaces of the bone, when they are commonly known as exostoses, or they may form diffuse overgrowths of a portion of the bone itself. The commonest form of exostosis is that which grows from the surface of a long bone near the end of the diaphysis, and which is composed of cancellous bone and is covered with a cap of cartilage. It is thought that the origin of this tumour is an abnormal growth from a remnant of epiphyseal cartilage which has become displaced. These cartilage-capped exostoses may be single or multiple, and any one of them may be pedunculated, or may be sessile and

attached to the shaft of the bone by a wide base. The lower end of the femur and the upper end of the humerus are favourite sites, but the epiphyseal region of almost any bone, long or otherwise, may be affected. These exostoses usually grow during childhood and adolescence; in adult life the cartilage cap disappears and growth ceases. When there are multiple

Fig. 340.—Skiagram of a cancellous exostosis arising from the external bicipital ridge of the humerus. (Walsham.)

exostoses, the patient is usually stunted in growth, and certain particular bones may be short and lead to deformity. The ulna and fibula are the bones in which shortening most commonly occurs. Cartilage-capped exostoses may be safely removed when they are single; when they are multiple, it is usual to remove only such growths as interfere with the full function of a joint or muscle. Sometimes a bursa arises over the exostosis; in this case the exostosis should always be removed.

Plate 20.



A myeloma arising in and expanding the lower end of a femur. Immediately above the growth the compact tissue and marrow are healthy. (St. Bartholomew's Hospital Museum.)

Many exostoses are of an entirely different nature. Some are inflammatory, as, for example, the small exostoses not uncommonly found under the nail of the great toe in conjunction with ingrowing toe-nail; others, which arise in tendons which have been subjected to constant strain, are possibly inflammatory. The most frequent of these take the form of an ossification in the adductor longus tendon where it arises from the pelvis, ossification in the attachment of the adductor magnus to the adductor tubercle of the femur, and an exostosis of the inner side of the head of the tibia where the sartorius, semi-tendinosus, and gracilis are inserted; the latter is more common in patients who suffer from knock-knee.

Fig. 341. — Subungual exostosis of the great toe.

Exostoses occur on the skull; they may form small sessile growths on the surface of the frontal bone which progress very slowly. So long as they project outwards and are not so situated as to be subject to pressure or friction they give no trouble. Occasionally, however, they project on the inner surface of the skull, or in the auditory meatus, or in the orbit; in these situations it may be necessary to remove them. Some of these exostoses of the skull are densely hard and difficult to cut (ivory exostoses).

**Fibromata and lipomata.**—Fibromata and lipomata form very rare tumours of the periosteal layer of bone. Their diagnosis is practically impossible before operation. They are usually discovered as deep-seated tumours closely adherent to the bone and casting no shadow in an X-ray, and are thought to be malignant growths until an incision proves them to be encapsuled periosteal or subperiosteal tumours.

**Endosteal tumours.**—Non-malignant endosteal tumours of the bone form a composite group, very complex in nature and difficult to describe. Very rarely simple chondromata and fibromata occur. More often, endosteal tumours are composite structures containing a mixture of tissues resulting from the metaplastic changes in the bone and marrow and leading to the production of either (1) a myeloma, the chief change being an overgrowth of the giant-celled tissue of the marrow, or (2) a cyst, in which the chief change is an excessive activity of the giant cells, producing absorption of bone, or (3) fibrocystic disease, when there is much metaplasia of marrow into fibrous tissue, a few small cysts only being formed.

Fig. 342.—The end of a great toe to show the characteristic appearances of a subungual exostosis.

1. **Enchondromata,** that is, tumours composed of cartilage, are very rare except in the phalanges and metacarpal and metatarsal bones. These tumours expand these bones, often to a very considerable size; they are found, as a rule, in children, and grow for some years, eventually, however, reaching a stationary condition. They are important because by their size they may injure the neighbouring joints, deforming the fingers and interfering with the use of the hand. They are commonly multiple, and may involve almost every phalanx. The diagnosis gives rise to no difficulty, the expansion of the bone by what appears in the X-ray to be a cystic condition being quite characteristic. The only conditions requiring differentiation are a dactylitis due to tuberculosis or syphilis; in these there are definite evidences of inflammation, and the X-ray appearances show in the one case a necrosis with periosteal

thickening, in the other a diffuse enlargement of the bone. Enchondromata should be exposed by operation and thoroughly curetted out from the centre of the phalanx at an early stage, before they grow to such a size as to produce a serious deformity or disability. When the growths have reached a considerable size, surgical treatment is much more difficult, and in extreme cases it may be impossible. When an enchondroma is shelled out or curetted, it will often be found that its centre is cystic, owing to myxomatous degeneration having occurred. There need be no fear that this or any other change indicates malignancy. Sarcomata associated with the bones of the hand are unknown. When enchondromata have been removed by curetting, X-rays of the bone taken at intervals demonstrate that new bone grows and gradually reconstructs the phalanx or metacarpal in its proper shape.

2. **Myelomata** form a very definite group of tumours; they occur in the

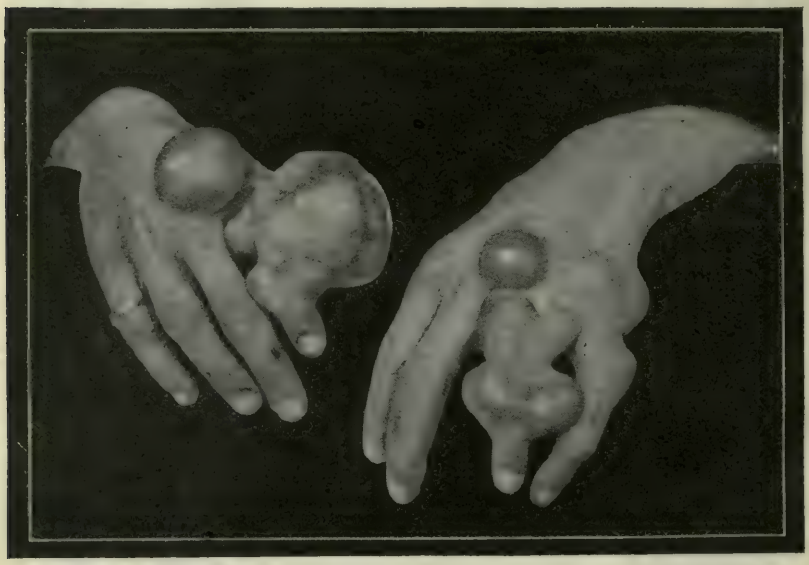
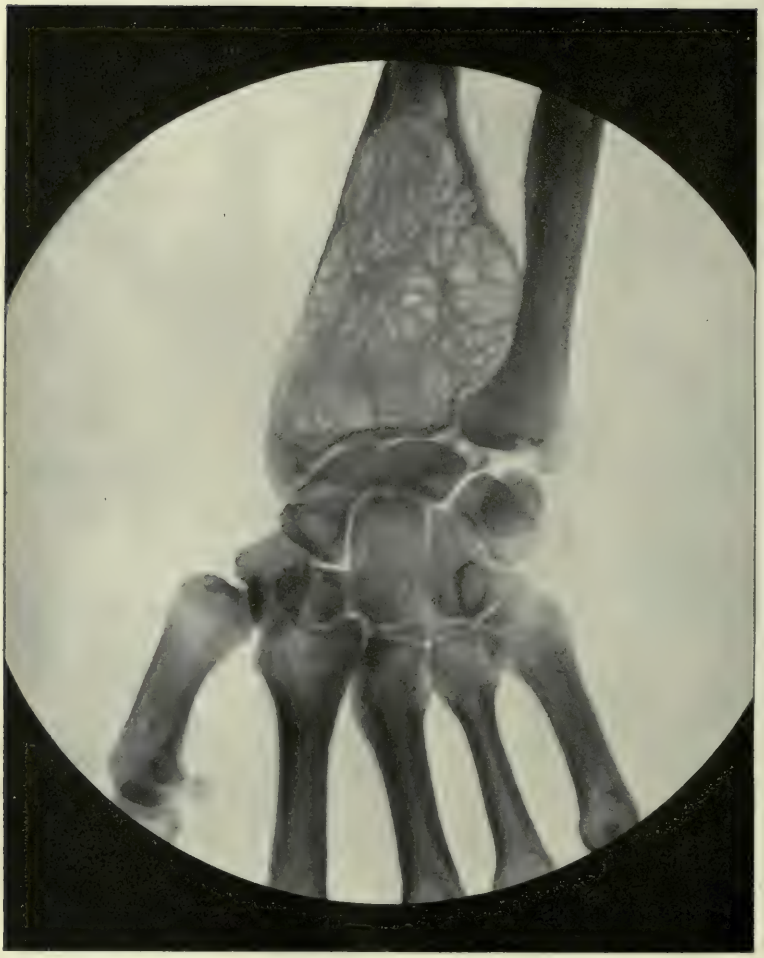


FIG. 343.—Multiple enchondromata of the metacarpal bones and phalanges.

interior of the long bones either in young people or in adults, always near the extremities of the diaphyses. Certain situations are particularly prone to the formation of myelomata. Of these the most important are the lower end of the radius, the lower end of the femur, the upper end of the tibia, and more rarely the clavicle. A myeloma produces a slow, steady expansion of the bone. In an X-ray this expansion is seen to be due to a well-defined tumour with an appearance as of a cyst divided up into a number of loculi by bony intersections. Clinically it is sometimes possible to feel that the bone can be indented at some spot where its shell is thin, a feeling of "egg-shell crackling" being produced. Very rarely myeloma destroys the external shell of the bone completely and expands into the surrounding tissue. Even then the condition is not malignant, but is due only to local expansion. When expansion to this degree has taken place a spontaneous fracture of the bone may occur. The only difficulty in the diagnosis of the myeloma is to distinguish it from a simple cyst. A certain diagnosis is impossible. A guess has to be made, based upon the

Plate 21.



Myeloma of the lower end of the radius. (Skiagram taken by Dr. Hugh Walsham.)

fact that in certain situations myeloma is more common, in other situations cysts more frequently occur. From the practical point of view the diagnosis is not very important, as the treatment of the two conditions is similar.

Microscopically myelomata consist of a spindle-celled tissue of a rather open texture, like an immature fibrous tissue. In the meshes of this tissue, which is very vascular, are large numbers of giant cells resembling, and in fact probably identical with, the osteoclasts of bone marrow. The bone around shows that an active process of lacunar absorption is taking place.

The *treatment* of a myeloma depends upon its situation and size. It must be understood that the tumour is not malignant, that is, will not recur if thoroughly removed and will not under any circumstances disseminate and give rise to metastatic growths. It will, however, if it is permitted, expand and destroy the bone and spread into the tissues around, interfering with the functions of muscles and joints; the indications then are for a thorough local removal with as little injury to the adjacent structures as possible. In some cases incision into the myeloma and curetting is sufficient; in fact, this with perhaps a thorough swabbing out of the cavity with a destructive antiseptic, such as pure carbolic acid (in order to destroy any remaining myeloid tissue), is the best method of treatment in any case in which the bone has not been greatly expanded, so that its surfaces, more particularly the joint surface, are intact. Treatment of a myeloma by curetting is, however, not entirely free from danger. In several cases severe hæmorrhage has occurred, necessitating immediate amputation of the limb and sometimes leading to loss of life. Sometimes a myeloma is only seen and diagnosed when it has grown to such a size that it is impossible to save a sufficient shell of bone around to preserve the normal anatomical structure. It may then be necessary either to excise the whole of the affected portion of the bone or to amputate the limb. In the upper limb conservative treatment is essential. Excision of the affected area followed by replacement by grafting, as far as this is possible, will be the correct treatment. In the lower limb, if so much bone has to be excised that it is doubtful whether the limb remaining will be capable of weight-bearing, an amputation will probably be preferred. Large myelomata of the lower end of the femur or upper end of the tibia in which the joint surfaces have been invaded are those which are most likely to necessitate amputation. At the present time, however, a myeloma should very rarely be allowed to attain such a size.

3. **Simple endosteal cysts.**—Simple cysts of the long bones occur most often in young people, and affect most particularly the upper part of the shaft of the humerus, the neck and trochanteric region of the femur, and the shaft of the tibia. Both clinically and in X-ray photographs they closely resemble myelomata, and diagnosis between the two conditions may be impossible. Cysts do not occur exclusively in young people, nor are they confined to the above-named situations. Thus if a cystic appearance is found in the head of the tibia in a middle-aged woman, although the probability is in favour of myeloma, the diagnosis between this and a cyst can only be made by exploratory operation.

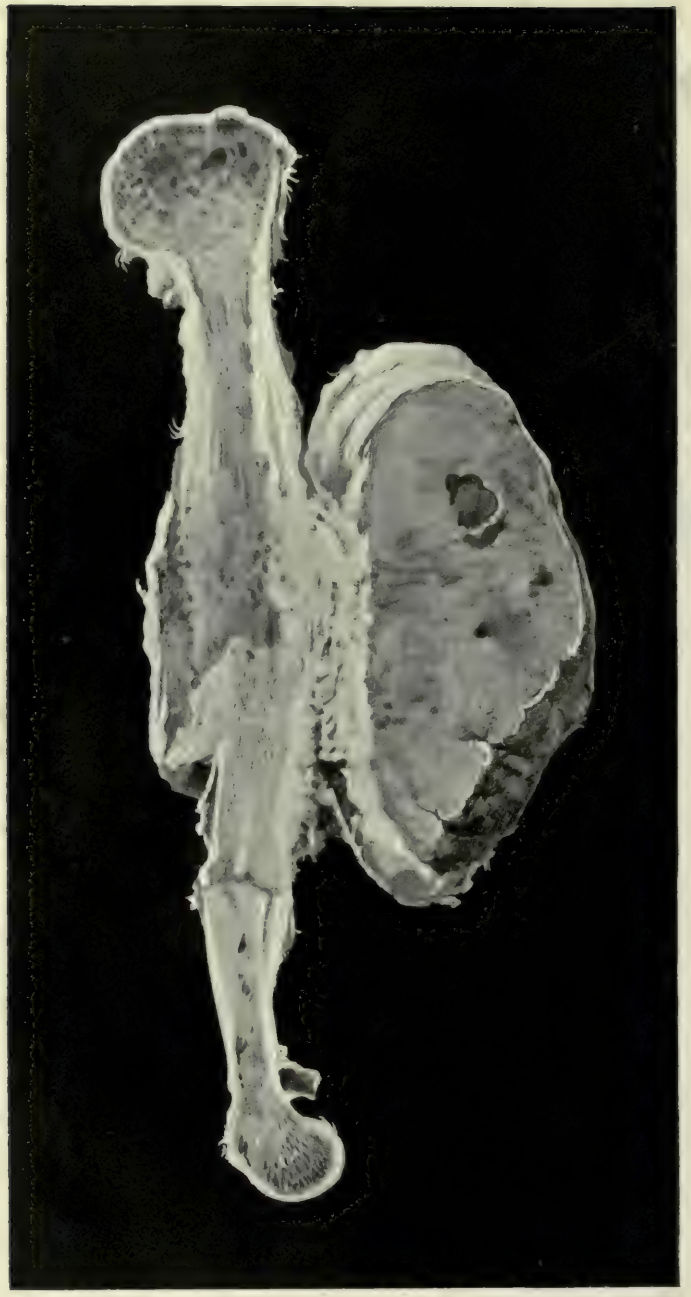
In a typical case of a simple cyst in a young person the first symptom will be either a fracture through the cyst, perhaps produced by slight violence, or the occurrence of chronic pain, or the discovery of an expansion of the bone, perhaps with deformity due to giving way where the shaft of the bone has been weakened by the cyst (see Figs. 199 and 200, p. 525). The X-ray appearances are similar to those of a myeloma except that the subdivision of a cyst by trabeculæ of bone is less marked.

Pathological changes found in and around the cyst vary a good deal in

different cases, and are of interest as showing the probable nature of the pathological process. The contents of these cysts is a clear straw-coloured fluid. Sometimes there is no lining membrane; sometimes a thin layer of grey tissue can be curetted out and shows a loose fibrous tissue with a spindle-celled structure, perhaps containing a fair number of giant cells. The bone in the

Fig. 344.—Skiagram of a case of fibrous osteitis of femur (Finzi).

walls of the cyst shows evidence of absorption by osteoclasts. Mingled with it there are often areas of cartilage and fibrous tissue, and sometimes portions of the latter closely resemble a myeloma in structure. The pathology of these cysts tends to indicate that they are formed by an excessive activity of the multinuclear osteoclasts, which do not, however, persist to form a myeloma, but leave a central cavity containing fluid. The changes in the bone around



A large myeloma of the humerus attached to the bone at the site of an old fracture. This must be regarded as an example of a marrow tumour springing from a portion of tissue displaced by the fracture. (St. Bartholomew's Hospital Museum.)

are capable of explanation as a reaction. In fact, it appears that simple cysts are closely related to myeloma in origin.

The treatment of a simple cyst is by incision, the removal of enough of its wall to give good access to its interior, and thorough curetting, followed by crushing in the wall to a slight extent in one or two places; this treatment leads to a considerable growth of new bone, thickening of the bone around the cyst and rendering it strong enough to resume its function. Excision of the affected region of the bone has been carried out, but is quite unnecessary.

4. **Fibrocystic disease.**—In a further group of cases most often seen in young people, a bone is expanded by a tissue which is largely composed of fibrous tissue, but which may contain cystic spaces in addition; the form in which there is a massive growth of fibrous tissue is seen most often in the tibia, the shaft of the femur and the skull. In the tibia the whole shaft of the bone may become filled up for a distance of several inches with fibrous tissue, which is at first spindle-celled, later densely fibroid in structure; the medulla disappears, and so does most of the compact bone, small irregularly disposed spicules of bone alone remaining in the fibrous matrix. The shaft of the tibia may be considerably expanded, and may give way under the weight of the body, bowing forwards. In the femur a similar condition may occur in the shaft, and may be complicated by the occurrence of cysts of considerable size involving the region of the trochanters and the neck of the bone. These conditions are entirely endosteal, are slow-growing and non-malignant. Although they are rare, their importance is great because they are usually mistaken for sarcoma, the limb being amputated.

Pathologically they may be considered to be due to metaplasia of the marrow cells, in which a large part is taken by the fibroblasts, so that, whilst much of the bone tissue is absorbed, there is an extensive formation of dense fibrous tissue which is not normally present in the bone at all.

*Treatment.*—When the condition is diagnosed sufficiently early it is amenable to treatment by linear osteotomy, exposing the whole affected region of the interior of the bone. If the fibrous tissue is curetted out thoroughly until normal bone is exposed, and the medullary cavity opened above and below, a reconstruction of the bone with disappearance of any symptoms of pain may be hoped for. It is necessary to preserve the limb from weight-bearing for a considerable period to enable it to attain sufficient strength. In cases in which this disease has progressed far and a severe deformity has arisen, a wedge of bone or of the new fibrous tissue has been successfully removed to correct the deformity, and union has taken place.

5. **Multiple fibrocystic disease.**—Simple cysts and fibrocystic disease occasionally appear in more than one bone in the same patient. Sometimes a simple cyst in one place co-exists with a fibrocystic condition in another. Multiple cystic disease is occasionally the cause of fragility of the bones. Rare cases have occurred of diffuse fibrocystic disease producing extensive deformities of a large part of the skeleton (Von Recklinghausen's disease).

**Primary malignant growths of the bone: Sarcoma.**—The differentiation formally observed between endosteal and periosteal sarcoma should be abolished, inasmuch as the so-called endosteal sarcomata are really myelomata and not malignant growths at all; the only classes of primary sarcoma of the bone which require differentiation from each other are parosteal and periosteal. Parosteal sarcoma is a rare tumour growing closely around the bone on the periosteum, and invading the muscular attachments; clinically it is a tumour rather of a muscle or of muscles. It may involve one muscle almost entirely, being attached to the bone only at the point at which this muscle is attached,

or it may involve a considerable area of the bone, including a number of muscle attachments and extending into the intermuscular planes. It forms a deeply situated tumour attached to the bone and growing with considerable rapidity. It does not tend to ossify, and therefore casts no bony shadow in X-ray photographs. It may be impossible to diagnose such a tumour from a parosteal fibroma or lipoma. Microscopically a parosteal sarcoma may be spindle-celled, round-celled or mixed-celled with secondary degenerative changes, but without calcification or ossification; the treatment is by amputation as for a periosteal growth.

Fig. 345.—Periosteal sarcoma of humerus. The subperiosteal and medullary extensions of the growth are well shown. (St. Bartholomew's Hospital Museum.)

Periosteal sarcoma is a more frequent type of growth. It forms a deep-seated tumour, insidious in its origin, the first symptom being pain or the discovery of an actual swelling. The tumour is found fixed firmly to the bone by a broad base, and an X-ray photograph will generally show very definitely the nature of the condition. Usually in the photographs there is evidence of destruction of the normal architecture of the bone, the line of compact tissue becoming thinned out or even disappearing as it enters the tumour. In some cases when there is little ossification in the growth there is an appearance as if a considerable part of the bone had been absorbed; in others ossification is extensive, and, with the disappearance of the normal architecture, there is a replacement by spicules of bone directed most often at right angles to the line of the shaft, and extending beyond the normal limits of the shaft into the growth around. Although these changes are usually characteristic, it sometimes happens that in central necrosis there is much thickening of the shaft of the bone around, giving externally the appearance of a tumour, and in this new inflammatory tissue the normal architecture of the bone may be to a large extent lost and replaced by bony spicules directed at right angles to the shaft. Hence it is necessary to secure an X-ray photograph which shows the structure of the central part of the bone with considerable accuracy, so that a central sequestrum, if present, may be demonstrated. This point in the diagnosis is particularly important, because, as will presently be mentioned, the microscopic diagnosis of a periosteal sarcoma is not always a simple one.

A periosteal sarcoma may be round-celled, spindle-celled or mixed-celled. Its microscopic appearance is usually complicated by the occurrence of patches

of fibrous tissue, cartilage and bone in the growth, so that these tumours are often termed ossifying sarcomata. It is not certain that the fibrous, cartilaginous and bony constituents of the growth are really part of the sarcoma; it is possible that they constitute a reactionary overgrowth of the bony elements in which the more truly malignant cells lie. In chronic inflammation of bone, fibrous tissue, cartilage and bone of an irregular nature may all occur, so that in a microscopic section of a doubtful bone tumour it may be impossible to make an accurate diagnosis unless definite cellular or nuclear changes characteristic of a sarcoma are discovered.

*Treatment.*—Periosteal sarcoma is a very malignant type of tumour. The

FIG. 346.—Sarcoma of the ulna. (A photograph kindly lent by Mr. G. P. Newbolt.)

degree of malignancy varies to some extent with the microscopic nature of the tumour, to a greater extent with its situation. The general rule for treatment is that amputation should be carried out at as early as possible a time and through the bone of the limb segment above that which is involved. Thus for sarcoma affecting the tarsus amputation should be carried out through the leg, for sarcoma of the tibia amputation through the thigh, for sarcoma of the femur through the hip joint. The chance of preventing recurrence in certain sarcomata, more particularly those of the femur and humerus, is very small, but the growths, if they are allowed to enlarge, sooner or later give rise to very severe pain, and amputation before this occurs certainly relieves the patient very considerably. Owing to the bad prognosis in sarcomata of

bones, treatment by non-operative methods which are more or less experimental, for example, by X-rays, radium, Coley's fluid, etc., may be considered to be justifiable, as also may treatment by local excision of a parosteal sarcoma followed up with treatment by one of the above-named methods.

FIG. 347.—Secondary carcinoma of the humerus. Spontaneous fracture. (St. Bartholomew's Hospital Museum.)

**Secondary new growths of bone.**—The secondary growths which occur in bone are of many different varieties. They are generally endosteal in origin, and may first give evidence of their presence by the occurrence of pain, by the discovery of a swelling, or by a fracture taking place through the growth. Secondary sarcomata in bone are most often secondary to a melanotic growth; carcinomata are secondary to a growth of the breast, of the prostate, or of the thyroid gland. But almost any form of secondary growth may occur. A curious form is the secondary thyroid tumour, which may be found in a bone which it has expanded, the tissue closely resembling normal thyroid tissue, and no tumour of the thyroid gland itself being discovered until after the bone growth has been explored. The primary thyroid growth may be very small, and may not show any activity.

It may be advisable to explore secondary new growths of bone in order to complete the diagnosis, and it may even be advisable to remove them either locally or by amputation in order to relieve the patient of pain. But this treatment is of course in no sense curative.

## The Differential Diagnosis of Endosteal Tumours.

A tumour which expands one of the long bones may be any one of a large number of different pathological conditions. Of these the principal are :—

1. Inflammatory tumours, *i.e.*, central abscess, tuberculous or septic, and central gumma.
2. Simple cyst.
3. Fibrocystic disease.
4. Myeloma.
5. Enchondroma.
6. Endothelioma.
7. Secondary carcinoma and sarcoma and two very rare conditions, hydatid cyst and aneurysm.

To take the last named first. True aneurysm of bone has occurred only in traumatic cases, the aneurysmal sac which expands the bone being an extension from an extraosseous traumatic aneurysm. This fact, that there is a sac external to the bone, will as a rule enable the diagnosis to be made. Hydatid cyst of a bone is practically unknown in England, although it is not very uncommon in countries in which hydatid disease is of frequent occurrence. It causes expansion of the bone by a cystic tumour, which shows subdivision into compartments in an X-ray photo-

graph. In many cases the first evidence of the presence of the cyst has been the occurrence of a spontaneous fracture.

The most important points to be observed clinically and in X-ray photographs in arriving at a diagnosis are :—

1. The situation of the tumour. As mentioned, myeloma, cyst, fibrocystic disease and enchondroma have each certain situations which they favour. But diagnosis by situation is by no means certain. Enchondroma has been found in the humerus and in the fibula, cysts in the metacarpal and metatarsal bones, and central abscess may occur in any situation.

2. The nature of the cortical bone. As a rule, thinning to the point of complete destruction of the cortical bone, particularly if there is a "fuzzy" appearance, favours a secondary malignant tumour (sarcoma or carcinoma).

3. The extent of the subdivision of the cystic space by bony trabeculæ. Trabeculation is most marked in a myeloma, less so in a simple cyst, and less so still in fibrocystic disease. In abscess and in malignant growths subdivision is usually absent. A cyst through which a fracture has occurred and healed may be extensively subdivided. An enchondroma is usually not much subdivided, but may show irregularities of density, due to the occurrence of bony masses.

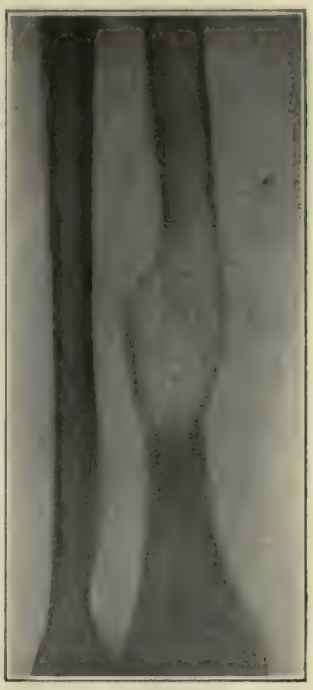


Fig. 348.—Skiagram of a case of thyroid tumour of radius. (Finzi.)

4. The presence of sclerosis of the surrounding bone, which is in favour of an inflammatory tumour.

5. The presence of new periosteal bone, again in favour of an inflammatory origin, unless a fracture has occurred.

6. The length of the affected bone. In true new growths and cysts the bone will be unaltered in length. In enchondroma and in fibrocystic disease it may be shortened ; in inflammatory tumours it may be lengthened.

When all evidence has been summed up, the diagnosis may still be obscure, and it may only be possible to complete it by an exploratory incision, perhaps with a microscopic examination carried out at the time.

# Section XIX.

## INJURIES AND DISEASES OF JOINTS.

### General Anatomy.

In a diarthrodial or freely movable joint the ends of the bones are covered with articular cartilage in place of the periosteum which covers the remainder of the bone. The bones are linked together by ligaments and a fibrous capsule, which are lined by a vascular synovial membrane secreting a fluid to lubricate the articular surfaces. Between the synovial membrane and the capsule there is a variable amount of connective tissue and fat, and in certain situations synovial folds and villi are formed by protrusions of fat towards the interior of the joint.

The synovial membrane consists of an inner layer having many connective-tissue cells arranged rather irregularly, parallel to the surface, and without a basement membrane or other line of demarcation separating them from the endothelial cells lining the joint. The outer layers consist of connective tissue with few cells. Branches of the articular vessels run to the synovial surface, forming tortuous vascular loops. Fat cells, and, in places, cartilage cells, are found, but no glandular cells. The synovial membrane very slightly overlaps the edge of the articular cartilage. The articular cartilage is non-vascular, and is of the hyaline variety, with several rows of cells lying in strata parallel with the surface, and without any endothelial covering. The deeper layers in contact with the cancellous bone show calcification. In children the articular end of the bone is separated from the diaphysis by the epiphyseal line, which in some joints, *e.g.*, the hip, is intra-articular.

### General Examination of Joints.

The examination of a joint should be begun by observing the corresponding healthy joint on the opposite side and be completed by a survey of the other joints of the body to determine if a monarticular or polyarticular disease is present.

The principal points to be investigated are :—

**The history.**—Injury, existence of other diseases, *e.g.*, gonorrhœa and hæmophilia, and the duration and course of the condition complained of, are points to be inquired into.

**Physical examination.**—1. *Swelling* in the region of the joint as shown by obliteration of normal fossæ ; site of the swelling, whether outside the joint, when bony points will be obscured, or within the joint, when they will be in their normal relation to the skin ; whether the swelling is solid or fluid. If swelling is present it should be measured by comparing the circumference of the joints of the two sides.

2. *Heat.*—In superficial joints increased heat can be detected by the hand.

3. *Redness* of the skin may be observed over superficial joints.

4. *Pain.*—The presence or absence of pain and tenderness either in the joint itself or referred to some distant point ; whether the pain is caused by active or passive movements.

5. *Muscular wasting* and loss of tone in muscles. If present the amount of wasting should be measured by a tape, comparing the readings of the two sides at a definite distance from some bony landmark. Muscular spasm should also be looked for.

6. *Abnormality of position.*—If the joint is held in an abnormal posture, the amount of the fixed flexion, abduction, etc., should be expressed in degrees.

7. *Limitation of movement.*—Both passive and active movements should be investigated. In the case of the shoulder and hip, care should be taken that movement of the scapula or of the pelvis and lumbar spine is not mistaken for movement in the joint under examination. The amount of flexion, adduction, etc., obtainable should be expressed in degrees. The presence or absence of grating or pain on movement should be noted.

8. *The length of the limb* should be measured between fixed bony points and compared with that of the sound side. Any difference should be expressed as *true* lengthening or shortening. Care should be taken to have the two limbs in the same position.

9. *Auscultation* of the joint may reveal grating which cannot be felt with the hand.

In certain cases additional examinations may be made by :—

1. *Examination under an anæsthetic.*—Chiefly to abolish muscular spasm, and so to distinguish between limitation of movement due to this cause and that due to actual joint changes. An anæsthetic may be necessary for the examination of a very painful joint.

2. *Examination by radiography.*—This should always include an examination of the corresponding joint of the opposite limb. Screen examination gives little information.

3. *Exploratory puncture.*—Removal of fluid from the joint for pathological examination is essential for the correct diagnosis of many infections.

## Injuries of Joints.

### Wounds of Joints.

**A penetrating wound** of a joint is a grave injury, as contamination with micro-organisms is so liable to occur, and to result in septic arthritis and the consequent risk of pyæmia and death ; therefore every wound in the neighbourhood of a joint must be regarded with suspicion until it is certain that the joint cavity has not been opened. The only certain sign of penetration is the escape of the sticky synovial fluid, which may appear in the wound in the form of little drops of oil mixed with the blood ; this sign is often absent. As the consequences may be so serious and the diagnosis is often obscure, it is right in the majority of cases to submit the patient to an immediate operation. Pending removal to a place where an operation can be performed with proper aseptic technique, the skin should be disinfected and the joint immobilised on a splint to prevent contaminated material being forced into the joint from the wound and the diffusion of any existing infection into the deeper parts of the synovial cavity. On no account should the wound be probed.

**A punctured wound** made by a small, clean object may be treated expectantly by splinting and the application of a firm compression bandage. A certain amount of synovial effusion usually follows, which is absorbed after a few days. A close watch must be kept on the temperature and pulse rate. If these rise the joint should be aspirated, the fluid examined for bacteria, and preparations made for operation.

If the wound is made by a rusty nail or other rough object, it is safer to operate at once.

**A lacerated wound** always requires immediate operation. For the purposes of treatment lacerated wounds may be classified thus :—

1. Uncomplicated cases seen within a few hours of injury.
2. Cases complicated by fracture or dislocation of the articular ends of bones.
3. Cases not seen until septic infection and cellulitis of the superficial tissues has occurred.
4. Cases in which septic arthritis is present when the patient is first seen.

1. The object of treatment is to remove the whole of the contaminated tissues and secure healing by first intention. The wound of the soft parts should be cleanly excised down to the capsule by a sharp knife, which should cut through clean tissue. The knife should not enter the wound, which should be removed *en masse* like a cancer. The mere trimming of the soiled surfaces with scissors is useless, as the new raw surfaces are contaminated during the process. The wound in the capsule and synovial membrane is excised in the same way and the joint washed out with normal saline or a weak disinfectant by means of a Higginson's syringe. The synovial membrane and capsule are then sutured. The rest of the wound may either be sutured, or left open and secondary suture performed after a few days. The limb is then immobilised on a splint. If much effusion occurs into the joint it should be removed through an aspirating needle. The after-treatment consists in massage and gradually increasing movement.

2. The preliminary excision of the wound is done in the same way. If the fracture is such that a stable, mobile joint may be expected, completely detached fragments of bones are removed and any contaminated surface of bone chiselled away. Small cavities in the bone may be filled with free fat grafts obtained from the subcutaneous tissues. The joint is then closed; if necessary, by a plastic operation.

If the damage is more extensive, it may be necessary to perform a primary excision of the joint with the object, in the lower limb, of securing a stable joint by bony ankylosis, and in the upper a movable joint.

In some cases of extensive damage, especially if the patient is old and feeble, a primary amputation may be advisable.

3. Excision of the infected tissues is no longer possible. The wound should be enlarged and suitable incisions made into the infected tissues in order to provide adequate drainage. If this is thoroughly done and the joint is immobilised, the infection may not spread to the joint.

4. Where septic arthritis is already present or supervenes under observation, the treatment is that of septic arthritis in general. (See p. 839.)

## Sprains.

The term *sprain* is applied to an injury to a joint produced by suddenly moving it beyond its usual range of motion. The actual lesion may be either a simple stretching or a tearing of the tissues involved, which are : the synovial membrane ; one or more ligaments, tendons or muscles ; or the bone in the form of a very small fissured fracture or the tearing off of a small fragment at the site of attachment of a ligament. In severe sprains several of these lesions may be combined. A sprain is accompanied by an effusion of blood into the peri-articular tissues and usually into the joint cavity, and is followed by a synovial effusion and inflammation of the damaged tissues.

A sprain may be complicated by a gross fracture; by an injury to a large nerve or blood-vessel; or by some other disease; thus, in a gouty subject, a sprained ankle is usually followed by an attack of gout.

*Symptoms and signs.*—Severe pain is usually felt at the time of injury, and swelling due to hæmorrhage may be noticed at once. Usually the joint becomes distended after a few hours by a synovial effusion. The skin is tense, and the whole joint feels hot. Voluntary movement is diminished or abolished, and both voluntary and passive movement is painful. Tenderness on pressure, especially over the injured ligaments or tendons, is present.

Under proper treatment a simple sprain recovers completely in from a few days to one or two months. Many cases, however, lead to the condition known as chronic sprain.

**Chronic sprain.** In this condition a weakness of the joint persists with recurring swelling and often pain, limitation of movement and stiffness. This is usually due to too early and free movement or to prolonged immobilisation. The synovial membrane is chronically inflamed, and intra- and extra-articular adhesions may be present, or, on the other hand, the symptoms may be due to muscular weakness persisting after the joint itself has recovered.

*Diagnosis.*—Careful examination by putting tension on the various ligaments, and the discovery of spots especially tender on pressure, will in most cases enable an exact anatomical diagnosis of the injured structure to be made. Evidence of fracture or dislocation must be carefully looked for, and in all severe sprains a radiogram should be taken. In chronic cases tuberculous disease and osteo-arthritis must be borne in mind.

*Treatment.*—The immediate indications are to stop further effusion and relieve the pain by placing the joint at rest with the torn ligaments relaxed for a few days; to prevent inflammation, promote the absorption of the effused blood and inflammatory products, and to prevent stiffness. In slight cases seen early elastic compression by a very firm bandage, applied over wool about one inch thick to distribute the pressure evenly, will prevent further effusion and cause the absorption of any already present, and, at the same time, fix the joint sufficiently. This may be followed by strapping the joint and allowing the patient to use it.

In more severe cases with much effusion the joint should be placed in a splint for a few days and either an ice-bag or hot fomentations applied. If very greatly distended and painful, it may occasionally be aspirated. As soon as the swelling and pain begin to diminish, daily massage should be started and an elastic compression bandage applied in the intervals. The amount of massage is gradually increased and voluntary movements encouraged. It is very important that the muscles should be massaged as well as the joint in order to prevent the atrophy which will later give rise to disability. Baking in a hot-air oven or radiant-heat bath, and alternate douches of hot and cold water, are often of value. The joint is then supported by strapping, and gradually increasing use is encouraged. In the knee and ankle, strain may be taken off the damaged ligaments by thickening the sole one-third of an inch on the same side as the injury.

In a chronic sprain which is painful, treatment should be begun by fixing the joint until the inflammation has subsided. Where recurring effusion is probably due to adhesions, the joint should be put through its full range of movement under an anæsthetic and a compression bandage applied. Wasted muscles should be developed by massage and proper physical exercises. Massage, baking and douches are particularly useful in chronic sprain.

## Dislocation of the Semilunar Cartilages of the Knee.

This accident was first described by Hey under the name of *internal derangement of the knee.* The internal cartilage is much more frequently injured than the external, as would be expected from a knowledge of the mechanism of the trauma. The original displacement usually occurs when the limb is flexed, and rotated outwards with the foot on the ground. The rotation is thus one of the condyle of the femur on the tibia, a movement which can only take place during flexion.

*Varieties of injury.*—The cartilage is not merely separated from its attachment, but in nearly every case is fractured or torn to a greater or lesser extent. The following forms of injury are found :—

1. One end of the cartilage is torn from its attachment to the tibia.
2. A longitudinal tear of the cartilage exists, most often involving the anterior part.
3. A transverse tear of the cartilage.
4. A combination of (2) and (3), so that a loose tag is formed directed forwards or backwards.
5. Tearing of the cartilage from the coronary ligament. Usually a portion of the cartilage remains attached to the ligament, showing that this is merely a variety of (2).
6. Rarely a portion of cartilage may become quite separated as a loose body.

*Symptoms and signs.*—A sudden wrench is felt in the knee with sickening pain, and the joint is found to be " locked " in a position of flexion. After some manipulation a click may be felt, and the knee can then be straightened, but in many cases the knee remains locked until reduction is effected by a surgeon. A synovial effusion follows. If the initial injury is not efficiently treated recurrence of the dislocation is very common. The symptoms become less severe with repeated displacement, the pain and swelling are less, but the cartilage becomes easier to displace, and quite trivial movements, such as lifting the limb to brush the lower end of the trouser-leg, may cause the locking. The patient after a time learns how to replace the cartilage himself.

On examination of a knee in an interval between attacks, nothing objective may be found except a point of tenderness over the anterior end of the cartilage, *i.e.*, exactly in the joint line. After repeated displacements, the changes of chronic osteo-arthritis are set up, fibrillation of the articular cartilage, osteophytes and thickening of the synovial fringes. A chronic effusion may also be present, and there is invariably some wasting of the quadriceps, particularly of the vastus internus.

*Diagnosis.*—The diagnosis depends largely on the history of the accident and the statement that locking, which persisted for some length of time, occurred. Somewhat similar symptoms may be caused by thickened synovial fringes and by loose bodies in the joint, but the initial symptoms are milder, and locking, if it occurs, is only momentary. In some cases the diagnosis can only be made by operation. It is possible in some cases to demonstrate a displaced cartilage by radiography after inflation of the joint by air or oxygen.

*Treatment.*—1. *Of the initial lesion.*—Complete reduction of the displacement is necessary. This can be effected by fully flexing the knee and then extending it while internally rotating the leg ; if the patient can fully extend the leg, reduction is complete. The knee should then be firmly bandaged over cotton wool or fixed on a back splint. After about ten days the patient may

Plate 23.

Skiagram of a loose piece of cartilage (partially ossified) in the knee joint.
(Taken by Dr. Hugh Walsham.)

be allowed to walk with the splint on, as by this time healing is well advanced. In two to three weeks the splint may be abandoned, but the knee should be firmly bandaged to prevent sudden movements of the joint. The quadriceps muscle should be massaged to prevent atrophy. Complete restoration of movement should be secured in a month or five weeks. If a recurrence of the displacement then occurs further attempts to secure union by rest and fixation are useless, and an instrument to prevent rotation should be worn or an operation performed.

2. *Late reduction.*—Reduction can sometimes be secured several weeks after the displacement by manipulation under an anæsthetic, and is always worth trying. If the cartilage cannot be replaced, then operation is advisable. After reduction of a cartilage the patient sometimes complains of a feeling of weakness in the knee and slight recurring effusions. These symptoms are often due to slight intra-articular adhesions and wasting of the quadriceps. The treatment is to put the joint through its full range of movement under an anæsthetic and to develop the muscle by massage and exercises.

*Operative treatment.*—The operation of excision of a semilunar cartilage often gives very good results, though the results are not so uniformly good as many claim. The most careful asepsis must be observed. The operation is most conveniently performed with the leg hanging over the end of the table. After applying a tourniquet an oblique incision is made downwards and forwards over the anterior end of the cartilage. The internal lateral ligament should be carefully preserved. Generally, the removal of the anterior half or two-thirds of the cartilage is sufficient. The wound is closed without drainage and a tight bandage is applied over wool. After four days the patient is encouraged to begin slight movements of the knee as he lies in bed, the bandage preventing too free movement. At the end of ten days he may walk about, and begins to move the joint with greater freedom. Full movement should be restored at the end of three weeks. It is essential to see that exercises or massage and electrical treatment are instituted to develop the quadriceps if the weakness of the knee, which is often complained of after the operation, is to be avoided.

**Dislocations of joints.**—See Section XII.

## Diseases of Joints.

### Loose Bodies in Joints.

**Loose bodies** in joints may be either perfectly free or attached by a slender pedicle to the interior of the joint. They may be formed in many ways, of which the following are some examples :—

1. By the detachment of a piece of articular cartilage or of bone covered on one surface by cartilage.

2. By the proliferation of the cartilage cells which normally exist in the synovial villi and the detachment of the cartilaginous mass so formed.

3. By the formation of a fibrous nodule in a synovial fringe following on an extravasation of blood into it from some injury, or from chronic inflammation set up by repeated small injuries.

4. By the formation of masses of fibrin, subsequently rolled up into hard bodies by the movements of the joint, following some synovial effusion. These are sometimes tuberculous.

5. By the separation of osteophytes in osteo-arthritis.

6. By the development of sub-synovial pedunculated lipomata.

*Symptoms and signs.*—The knee is the usual site of loose bodies which give

rise to symptoms, though they may occur in any joint. The symptoms, which are due to the loose body being caught between the ends of the bones, are sudden pain and a momentary locking of the joint in a position of flexion. When the patient attempts to extend the limb the ends of the bones are forced apart, stretching the ligaments and giving rise to a sickening pain. The loose body then usually slips away and movement becomes free, but a synovial effusion usually follows and lasts for several days. The loose body may be felt to slip under the finger. If it remains constantly in one position it may be suspected of being attached by a pedicle, while if it can be moved to the other side of the joint it is probably free. The patient generally learns some trick of movement by which the body is rendered palpable, and, owing to the sudden way in which these bodies slip away under the finger, they have been called "joint-mice." An attack may only occur at long intervals, but sometimes recurs almost daily. If the latter, a condition of chronic synovitis is set up, an effusion is constantly present, and the ligaments are relaxed by constant stretching. Such a condition gives rise to a feeling of weakness in the joint, which is liable to give way and let the patient down. In long-standing cases osteo-arthritis is set up.

FIG. 349.—The formation of a loose cartilage in a joint. A little mass of cartilage attached by a slender stalk. (St. Bartholomew's Hospital Museum.)

Rarely a loose body may become attached in some synovial pouch and so cease to give rise to symptoms.

*Treatment.*—In some cases a laced knee-cap with a pad pressing on some particular spot will give complete relief, but in the majority it is better to open the joint and remove the loose body. This at once removes the source of the symptoms and prevents the onset of chronic joint changes. As the body may be difficult to find, it is well to fix it by transfixion with a needle before operation. When not at once visible it may be found by flushing out the joint by means of a forcible flow of normal saline solution from a Higginson's syringe.

## Arthritis: (A) Simple Traumatic Arthritis.

Often called simple synovitis. The affection is rarely limited to the synovial membrane, so that the term arthritis, which includes an affection of any or all of the structures comprising a joint, is more accurate. The condition is one of inflammation due to injury, either actual trauma or in some cases over-use, and not to infection by bacteria. It may be either acute or chronic.

(i.) **Acute simple arthritis** is caused by a sprain, dislocation, or contusion of the joint.

*Pathology.*—The synovial membrane becomes hyperæmic, and exudation of plasma and cells occurs into the membrane, which becomes more succulent, thickened and red. The endothelial cells lining the membrane may proliferate and be cast off into the joint. The fluid in the joint is increased by the serous exudate, which may be opalescent from the presence of cells or blood-stained. The ligaments may also be softened and relaxed. In severe injuries hæmorrhage may occur into the joint cavity. Fibrin is deposited from the

fluid on the synovial membrane, or fibrinous coagula float in the fluid. As repair occurs the fluid is absorbed and the synovial membrane is restored to its original condition, but in some cases, instead of resolution, a condition of chronic inflammation persists.

*Symptoms and signs.*—Swelling due to the fluid effusion occurs early, and there may be œdema of the peri-articular tissues. The joint feels hotter than normal and is generally painful and tender. In the most acute cases some redness of the skin develops. The joint is held in a characteristic position which varies with different joints, though in most flexion is prominent. Impairment of movement is due to the distension of the joint and to muscular spasm.

*Diagnosis.*—Simple arthritis must be distinguished from : (1) Peri-articular injury ; (2) Tuberculosis ; (3) Inflammation of neighbouring bursæ and tendon sheaths ; (4) Fractures of bones and ruptures of tendons and ligaments.

*Treatment.*—Treatment is detailed under *Sprain* (p. 833).

(ii.) **Chronic simple arthritis** is caused : (1) By previous acute arthritis ; (2) by chronic irritation of a joint by a loose body, thickened synovial fringe, recurrent displacement of a cartilage, presence of slight intra-articular adhesions, etc. ; (3) by lack of tone in the muscles.

*Pathology.*—The synovial membrane is thickened, effusion is present, though variable in amount, and the degenerative changes of osteo-arthritis tend to occur.

*Symptoms and signs.*—Swelling due to the effusion, general weakness of the joint due to relaxed ligaments and wasted muscles. Heat, pain and tenderness are usually absent. Movement is generally restricted in some degree, though a fair range is present.

*Diagnosis.*—The conditions from which it must be distinguished are : Osteo-arthritis, Charcot's joint, and tuberculosis with effusion. It must be remembered that an injury is often the origin of tuberculosis, and that the signs of chronic traumatic arthritis may pass almost insensibly into those of tuberculosis.

*Treatment.*—See *Chronic Sprain* (p. 833).

**Intermittent hydrarthrosis.**—Cases are occasionally met with in which a periodic effusion occurs into the cavity of a joint, commonly the knee. The times vary, but, as in malarial fever, each case has its period, which is observed in most instances with striking regularity. The intervals are seldom less than ten days or more than thirty. The attack is sometimes preceded by a definite " aura," *e.g.*, the sensation of " running water " has been noted. At the onset there is a varying degree of pain and stiffness, followed by an increasing effusion, which may remain moderate or become excessive. After two or three days the effusion subsides and the joint returns to normal. The condition may last for years, and nothing is known as to its pathology.

*Treatment.*—During the attacks the joints should be kept at rest, but no local treatment seems to influence or modify the periods of effusion. Quinine and arsenic have been given internally.

### (B) Infective Arthritis.

Inflammation of joints is caused by many varieties of bacteria and occurs also in certain specific fevers of which the causal organism is unknown. The infection may reach the joint through the blood-stream, by extension from adjacent bone or soft parts, or by direct inoculation through a

penetrating wound. For purposes of description the cases of infective arthritis will be classified under the causal organisms.

I. **Arthritis due to pyogenic cocci.**—Streptococcus and staphylococcus.

(*a*) **Acute suppurative arthritis.**—*Pathology.*—In the beginning the synovial membrane is most affected. It becomes highly vascular and of a bright red colour, and greatly thickened and succulent from exudation of fluid into its interstices. The surface loses its smooth appearance and becomes dull and opalescent; it is rapidly covered with shreds of fibrin and becomes converted into granulation tissue. The synovial fluid is increased in quantity by an outpouring of serum; it is at first opalescent but rapidly becomes converted into pus; in the more acute cases it is blood-stained. The cartilages lose their pearly appearance and become dull and yellow; they become vascularised, and ulcerate in places. They may be raised in patches by granulations springing from the bone and later undergo necrosis and be cast off into the joint cavity. Finally, the cartilage is entirely replaced by granulation tissue. The ligaments become softened and eroded, so that pathological dislocations may occur. The articular ends of the bones are absorbed, and sequestra may form. Spiky masses of new bone spring up from inflamed periosteum. The pus soon bursts through the capsule of the joint and burrows into the tissues of the limb, sometimes for surprising distances. If repair occurs, the opposing joint surfaces, lined by granulation tissue, and later, young fibrous tissue, fuse together, and fibrous ankylosis takes place. True ankylosis by bone occurs more frequently after suppurative arthritis due to the pyogenic cocci than after any other disease of joints. A movable joint only results when treatment has been commenced in the early stages.

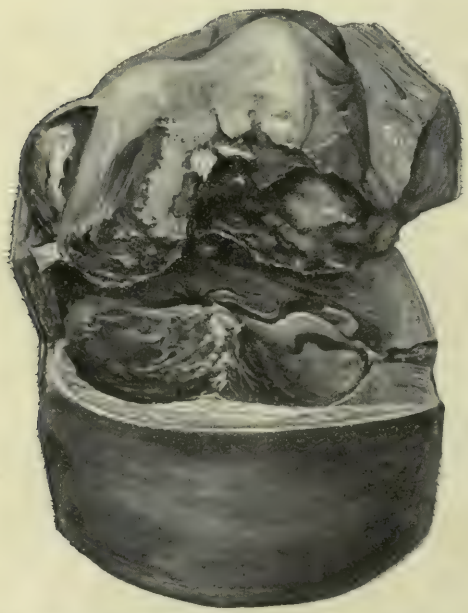


Fig. 350.—Suppurative arthritis showing extensive ulceration and destruction of the synovial membrane, articular cartilage and crucial ligaments. The bony surface of the femur and tibia has become deeply excavated by ulceration. Duration of the disease, two months. (St. Bartholomew's Hospital Museum.)

*Symptoms and signs.*—Soon after the onset pain is felt in the joint, especially on attempted movement. It soon becomes intense, and swelling, which rapidly increases, is found. The temperature rises to 102° or 104°, the pulse rate to 110, 120, or higher, and the patient looks exhausted and ill. Rigors often occur. If not relieved by incision the swelling and pain in the joint increase and the skin becomes red and œdematous, while the temperature and pulse rise still further and the patient becomes prostrated, with a dry, brown tongue. Delirium comes on, and death occurs from septic poisoning and exhaustion.

*Treatment.* In the early stages of cases which are not due to direct extension from bone, the joint should be incised, the fluid evacuated and the joint washed out with normal saline or a mild disinfectant lotion. In certain instances the joint may be sutured without drainage and the limb carefully splinted. In the majority, however, drainage should be instituted.

Where frank pus is present in the joint, free incisions to evacuate the pus should be made and continuous irrigation carried out with normal saline or with Dakin's fluid through Carrel's tubes inserted into the joint. The joint should be immobilised and sufficient weight extension applied just to separate the joint surfaces without unduly stretching the ligaments. Rigid tubes should never be inserted into a joint, and even the soft Carrel's tubes should be withdrawn to the surface as soon as possible.

In more advanced cases, in which destruction of the cartilages has occurred, excision of the joint may be done to facilitate drainage, and amputation may be necessary sometimes as a life-saving measure when the patient is going downhill rapidly. The latter should not be delayed so long that the patient loses his life in spite of it. The after-treatment is detailed under *Stiff Joints* (p. 857).

(*b*) **Pyæmic arthritis.**—In pyæmia, several joints in succession may be affected. The condition tends to be subacute. Pain is not a prominent feature and soon passes off. A little swelling with œdema over the joint and great limitation of movement persist, and are accompanied by rapid wasting of muscles. Grating may be felt on attempted movement. If a joint in this stage is opened, it is found to contain a small quantity of inspissated pus, the cartilages are eroded and the ends of the bones exposed.

*Treatment* is by early incision and drainage followed by immobilisation in a good position.

(*c*) **Arthritis secondary to disease of the neighbouring bone.**—Acute septic arthritis is frequently caused by direct extension from bone. The symptoms are those of septic arthritis in general, and when infection occurs in the articular ends of a long bone, every attempt should be made, by early incision into the bone and immobilisation of the joint, to prevent its extension to the latter. If infection of the joint has occurred incision and drainage should be performed forthwith. In cases in which separation of the epiphysis has occurred with joint infection, amputation should be performed early if the patient is losing ground and the temperature does not fall after incision.

(*d*) **Acute arthritis of infants.**—This very fatal disease occurs usually in children under the age of one. It is caused by infection spreading from the growing end of the diaphysis immediately under the epiphyseal cartilage into the joint, and is characterised by sudden onset and rapid progress. The knee, hip and shoulder are the joints most often affected. The articulation attacked becomes flexed and stiff, pain and swelling soon follow, and the joint rapidly becomes distended with pus, which passes through the capsule and burrows in the soft tissues around.

*Treatment* is by early incision and drainage. In the case of the hip joint, early excision of the head of the femur gives the best chance of recovery, though the functional result is poor.

II. **Pneumococcal arthritis.**—Pneumococcal arthritis is of comparatively rare occurrence. It is commonest in childhood, 34 per cent. of the recorded cases having occurred in children under the age of five. The disease is usually secondary to pneumonia, though occasionally to pneumococcal infections in other sites, *e.g.*, the middle ear. Primary infection, with no other discoverable lesion, occurs in a small proportion of the cases. One or more joints may

be affected, but usually the disease is monarticular, the larger articulations, especially the knee and shoulder, being most frequently involved.

*Pathology.*—The changes in the joint are those of suppurative arthritis in general, but the destructive changes in bone and cartilage are less marked. The effusion is occasionally serous, but usually greenish-yellow pus, containing semi-translucent coagula, similar to the contents of a pneumococcal empyema, is found.

*Symptoms and signs.*—The clinical picture is that of an acute arthritis with swelling of the joint, peri-articular œdema, tenderness and heat. A distinctive feature is that the skin is not reddened as it is in most other forms of suppurative arthritis. The temperature is moderately high, 102°—103°. In children, the general condition is often surprisingly good, the patient eating and sleeping well.

The *diagnosis* is made certain by exploratory puncture and examination of the fluid.

*Treatment* consists in early incision and irrigation. If the effusion is still serous, the joint may be closed, but otherwise the joint must be drained for a few days.

*Prognosis.*—The prognosis as to life is grave, but if the patient recovers the function of the joint is generally good.

III. **Gonococcal arthritis.**—Arthritis is a not uncommon complication of gonococcal infection of the urethra or vagina. It may occur also in the vulvo-vaginitis of children and in gonococcal conjunctivitis. The larger joints are usually affected, but the smaller ones, such as the sterno-clavicular and temporo-maxillary, are not exempt. Several joints may be involved at one time; usually, however, only one joint at a time is attacked, and the knee most commonly of all.

The gonococcus has been isolated from the affected joint many times, but, as a rule, is difficult to obtain, so that formerly the disease was supposed to be due to toxins circulating in the blood-stream. In some cases the arthritis is due to secondary infection and not to the gonococcus itself. There are several clinical varieties of the affection.

1. *The arthralgic type.*—Characterised by pain in one or more joints, often moving from joint to joint, with no physical signs of inflammation. This is often known as *gonorrhœal rheumatism.*

2. *Acute or subacute arthritis.*—The majority fall into this group. It occurs early in an attack of gonorrhœa, and resembles any other attack of acute arthritis except that there is generally more peri-articular swelling. Effusion is often rapid and considerable, and the pain is intense. There is redness and œdema round the joint and general constitutional disturbance. It is sometimes monarticular, but one joint after another may be attacked and the effusion may subside in one joint as another is infected. It may completely resolve or pass into a chronic form.

3. *Chronic plastic arthritis* is often polyarticular. In many cases the onset is gradual, though it may follow an acute attack. It is characterised by a small effusion which is followed by chronic peri-articular and synovial thickening. There is little pain unless the joint is used actively. Fibrous adhesions readily form, and in neglected cases destruction of the articular cartilages precedes firm fibrous or bony ankylosis in a deformed position.

4. *Suppurative arthritis.*—In a few cases, during the acute stage of the urethral infection, an acute suppurative arthritis occurs. This is usually due to a secondary urethral infection with pyogenic organisms, but occasionally to the gonococcus alone. Firm bony ankylosis may result.

5. A type which affects the small joints of the hands or feet with involvement of the sheaths of the overlying tendons, giving rise to much deformity and crippling.

The *diagnosis* is made from the history and by obtaining the gonococcus from the initial lesion. In cases of old-standing gleet this may be very difficult.

*Treatment.*—The first essential in treatment is the cure of the urethritis or other source of infection (see Section XXVIII.).

*Local treatment.*—1. *The arthralgic type.*—Improvement usually rapidly follows cure of the urethritis. In obstinate cases pain can be relieved by counter-irritation with liniment of iodine or methyl salicylate, or by blistering.

2. *The acute type.*—The joint must be immobilised until the acute symptoms have passed off, and pain is often so severe as to render morphia necessary. A faulty position of the joint should be rectified by weight extension. When the acute inflammation has subsided and a chronic effusion only remains, vigorous treatment by massage, counter-irritation, etc., is necessary to restore mobility to the joint.

Aspiration followed by pressure should be employed if effusion is persistent in the knee joint; if the fluid reaccumulates the joint should be incised, washed out, closed and firmly bandaged. If, in spite of aspiration and irrigation, fluid returns, it is probable that some form of infection remains in the prostatic urethra which has escaped recognition.

The treatment of acute suppurative arthritis is dealt with on p. 839, and of fibrous adhesions on p. 857.

If fibrous ankylosis with a small range of painful movement has resulted, it is wise in the case of the knee, wrist and ankle, to fix the joint in good position by a celluloid or some other form of splint and to await firm ankylosis.

In the case of the shoulder, elbow or hip, attempts to maintain some range of mobility should be persevered with, and, if a useful joint is not secured, some form of arthroplasty should be discussed.

If a firm stable knee or ankle is not secured, an excision, to obtain firm bony union and a straight and painless limb, should be recommended.

*Treatment by vaccines.*—Autogenous vaccines have occasionally given good results in the last few years, but a stock vaccine seems to be without much value. In obstinate cases they may be employed.

IV. **Arthritis in typhoid fever.**—Monarticular or polyarticular arthritis due to the bacillus typhosus may arise in the course of enteric fever. The hip-joint is the one most frequently affected. Pus is not often found, but a large serous effusion forms, which, in a large proportion of the cases, leads to a pathological dislocation of the joint. Recovery takes place in some cases with a freely movable joint, but in others with fibrous ankylosis.

*Treatment* should be directed towards fixing the joint and preventing dislocation. If the effusion is large, it may be aspirated.

Septic arthritis due to the streptococcus or staphylococcus occurs also during the course of typhoid fever. It differs in no way from the ordinary forms of septic arthritis, but, owing to the exhausted condition of the patient, the prognosis is bad, the majority of cases proving fatal.

Infective arthritis also occurs occasionally in the course of scarlet fever, influenza, bacillary dysentery, Malta fever, glanders, variola, measles, diphtheria, and meningococcal meningitis.

V. **Tuberculous arthritis.**—Tuberculous disease of joints occurs most frequently in children and young adults, though people of any age may be affected. Ill-nourished children under bad hygienic conditions in large

cities are especially prone to the disease. A primary focus in the mesenteric or bronchial glands is usually present, and the localisation of the blood-borne infection to a particular joint is probably determined by some trivial injury.

*Pathology.*—The disease usually commences in the bone, either in the spongy bone of the epiphysis or in that immediately on the diaphyseal side of the epiphyseal cartilage. Primary synovial disease is uncommon.

*Changes in the bone.*—The tubercle bacillus, having passed into the tissues, gives rise to the formation of miliary tubercles, which enlarge, degenerate in the centre, and caseate. As they enlarge they coalesce. The bony trabeculæ are destroyed directly by the tuberculous tissue, and a condition of rarefying osteitis is also set up in the bone for some distance around the actual lesion. The latter is due to the stimulation of the osteoclasts by the chemical products of the bacilli. Occasionally death of a large piece of bone is caused, and so a tuberculous sequestrum is formed. The tuberculous process extends to the joint, either by passing under the edge of or perforating the articular cartilage, or by extension along the ligaments. In one of these ways tubercle bacilli are set free in the synovial fluid and, by movements of the joint, are soon diffused throughout the whole cavity. They then pass into the synovial membrane and set up a general diffuse tuberculous inflammation.

Fig. 351.—Tuberculous disease of the knee joint, showing pulpy thickening of the synovial membrane. (St. Bartholomew's Hospital Museum.)

*Changes in the synovial membrane.*—In the common form the synovial membrane becomes swollen and thickened (see Fig. 351). It appears more succulent than normal, and, in the early stages, semi-translucent. The swelling is due to the formation of microscopical tubercles and the infiltration of the tissues by small lymphocytes and œdema. The synovial membrane is gradually converted into a tuberculous granulation tissue, which destroys the endothelial lining, so that the surface loses its smooth appearance and becomes roughened and shaggy. The synovial fringes are thickened and prominent, and the tuberculous granulation tissue spreads over the edges of the articular cartilage and erodes it. The swelling of the joint is largely due to this increased thickening of the synovial membrane. The tubercles in the synovial membrane may go on to caseation.

In a rarer form, " nodular tubercle," the surface of the synovial membrane is covered with flat or pedunculated masses coated with a smooth layer of fibrin.

*Changes in the cartilages.*—The cartilages are gradually eroded by the tuberculous granulation tissue growing over them from the periphery, or between them and the bone, thus eroding them from their deep surface. In this way portions of cartilage may be actually separated and cast off into the joint, forming loose bodies. The process is hastened by pressure between the ends of the bones, and, as the cartilage is destroyed, the exposed ends of the bones come into contact with one another.

*Changes in the ligaments.*—The ligaments are involved in the tuberculous process, become œdematous and softened, and so allow displacement of the bones forming the joint to occur. Intra-articular ligaments, such as the crucial ligaments in the knee and ligamentum teres in the hip, are attacked early, because they are more or less completely surrounded by synovial membrane.

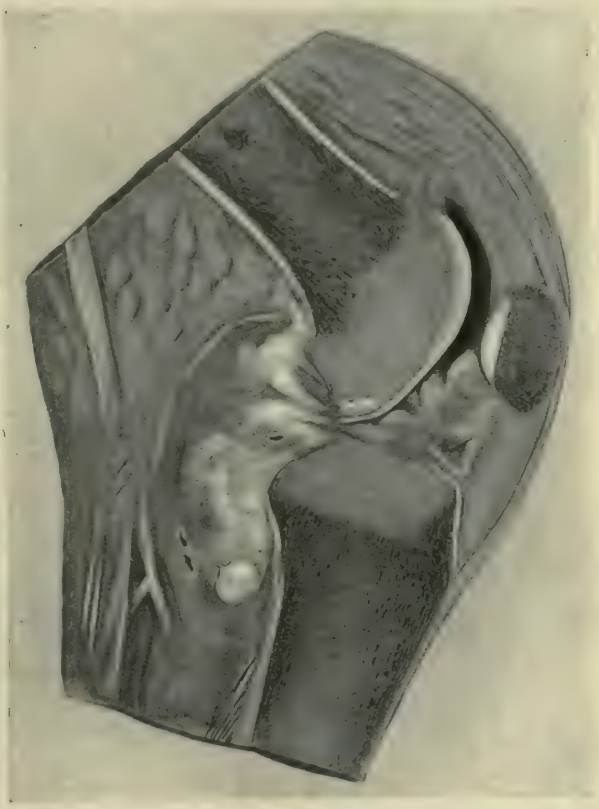


Fig. 352.—Tuberculous disease of the knee joint, showing erosion of cartilages and caseation of lymphatic glands in the popliteal space. (St. Bartholomew's Hospital Museum.)

*The synovial fluid.*—The synovial fluid is usually *very little increased in amount.* It becomes, at first, opalescent from the emigration of lymphocytes, and, later, turbid from the increase of the cells and the presence of fibrin and caseous matter. In some cases, in which much caseation has occurred in the synovial membrane, it is converted into tuberculous pus, and the joint becomes a tuberculous abscess cavity.

*Lymphatic glands* in the neighbourhood of the joint become infected and enlarge. They may break down and give rise to abscesses (see Fig. 352)

*Bursæ* in direct connexion with the joint share in the tuberculous process, and adventitious bursæ also may be formed by the protrusion of synovial pouches through gaps in the weakened capsule (Baker's cysts). The latter may have such a narrow connexion with the articular cavity that fluid cannot be reduced into the joint by pressure upon them. A clear, straw-coloured fluid, occasionally with flakes of lymph in it, is usually obtained by puncture. The cystic swelling may be present some time before clinical

evidence of disease in the joint itself appears; in this case it is reasonable to suppose that the disease began in a bursa and subsequently spread to the joint. Morrant Baker described these cysts as occurring most frequently in connexion with osteo-arthritis, but subsequent examination of his specimens has shown that the lesions are all tuberculous. Clinically the cysts appear in the limb as tense, rounded, fluctuating swellings covered by normal skin. They are not tender or painful. At a later stage the skin may become involved and appear red and œdematous. The cysts are usually situated in the neighbourhood of a joint, but may burrow for long distances in the intermuscular planes before coming to the surface. The nearest joint will usually show evidence of disease. Unless the accompanying disease of the joint is advanced, the cyst may be dissected out and the narrow neck of connexion with the joint ligatured (see Fig. 353).

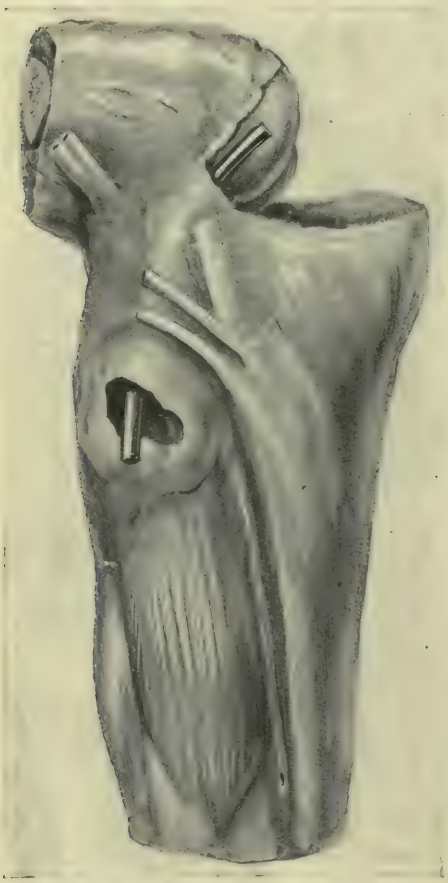


FIG. 353.—Baker's cyst in the popliteal space, passing beneath the popliteus muscle into the calf in a case of tuberculous disease of the knee joint. (St. Bartholomew's Hospital Museum.)

*Peri-articular abscesses* are formed by direct extension from the joint to the tissues around, within bursæ, or by infection of the lymphatic glands. They may travel long distances in the intermuscular septa before they approach the surface. These abscesses ultimately involve the skin, which gives way, and the tuberculous pus is discharged, leaving a sinus infected with pyogenic organisms.

*Course and termination.*—The course of the disease varies with the resistance of the patient and the stage at which proper treatment is begun. Efficient treatment in a very early stage will lead, in some cases, to complete resolution, and the restoration of a freely movable joint. Usually, however, there is some ultimate limitation of movement by fibrous adhesions.

In a later stage, where the formation of tuberculous granulation tissue is extensive and the articular cartilages are eroded, firm ankylosis by tough fibrous tissue or, very occasionally, bone, is the best that can be hoped for. In many cases, owing to lack of early treatment, the disease progresses, partial dislocation of the bones takes place owing to the destruction of ligaments, abscesses form and give rise to sinuses which become secondarily infected, and the joint is completely disorganised. In some, the disease may still be arrested and healing by fibrous tissue occur, but islands of infection are usually left behind, and

such joints are liable to recrudescence of the disease for years. A tuberculous process in a joint may terminate fatally from *prolonged suppuration, amyloid disease*, or from *acute miliary tuberculosis* affecting the meninges or the lungs. In rare instances, after an extensive, and sometimes after quite a small, operation, acute miliary tuberculosis develops.

*Symptoms and signs.*—In the great majority of cases tuberculous disease of a joint starts insidiously, develops slowly, and often makes considerable progress without attracting serious attention. Slight lameness, occasional pain, ascribed to "growing pains," and uneasy sleep, with now and then a fitful whimper, may be the only indications during the early months of an affection which may soon develop into a formidable disease.

The cardinal symptoms and signs are (1) lameness, (2) pain, (3) swelling, (4) limitation of movement, (5) muscular wasting, (6) deformity of posture, (7) shortening of the limb.

**Lameness.**—Lameness in the lower extremity, like impaired mobility in the upper extremity, is an early symptom which should always excite suspicion. It may be quite obvious, but often is only detected by careful and repeated examinations. Not infrequently it is intermittent, and is only noticeable after exercise or at the end of the day. It is due to reflex muscular spasm and to pain.

**Pain.**—Pain is by no means always present, either at the onset or during the subsequent progress of tuberculous arthritis. From the first it may be considerable and persistent, more especially in the case of the hip, but it may be entirely absent. At the onset of the disease it may only occur after exercise or during sleep, as night screaming (starting pains). Pain may occur in the joint itself, or it may be referred along distant nerves; thus pain is often felt in the knee when the hip is affected. Pain, when it occurs, is a valuable aid to diagnosis, but its absence must not be allowed to outweigh other evidence.

**Swelling.**—The swelling of a joint in tuberculous disease gives a characteristic doughy sensation. True fluctuation cannot be obtained, as a rule, as the enlargement is usually due to the pulpy thickening of the synovial membrane, and not to a fluid effusion. Swelling in the early stages may be very slight, and only detected by very careful comparison with the sound side and measurement, but, if a careful examination is made, some swelling will usually be identified in all joints except the shoulder. In the later stages, when the swelling is due to abscess of the joint, true fluctuation is, of course, easily obtained.

**Limitation of movement.**—Impaired mobility is the most trustworthy and usually the most constant symptom of joint disease. It is due to a reflex muscular spasm, by which nature attempts to provide rest for the affected joint. It has, however, the disadvantage of increasing the interosseous pressure within the joint. In most cases it is safe to conclude, if movement is entirely unrestricted, that the joint is healthy; nevertheless, it sometimes happens, after a short period of rest, that no limitation of movement can be detected, despite the existence of other signs of disease. If examination is repeated after the lapse of a few days and use of the limb, it may then be found that movement is defective. It is a mistake to employ an anæsthetic in the case of a nervous child, as, during anæsthesia, the muscular spasm is abolished and any limitation of mobility will be lost.

**Muscular wasting.**—In the early stages of the disease, wasting of the muscles, which act on the joint, is usually detected on critical examination, and is very marked when the disease is well established. It is accompanied by a loss of tone, which makes the muscle feel flabby to the touch. Taken

alone, muscular wasting may be of little diagnostic value, as it may be due to a variety of other causes (*e.g.*, infantile paralysis), but, when considered in conjunction with other signs, it becomes valuable. Extreme and rapid wasting may be taken as an indication of grave disease, and the converse is equally true. Wasting is most marked in that group of muscles which has the most powerful action on the joint involved, and is, no doubt, reflex in origin.

**Deformity of posture.**—In the earlier stages deformity of posture of a limb is due to muscular spasm. Thus the hip is held in a position of flexion, abduction, and external rotation. When the knee is inflamed, the leg is held slightly flexed and, in later stages of disease, is also rotated outwards and displaced backwards as the result of over-action of the hamstrings, or owing to relaxed ligaments.

In later stages deformity may be due to actual bony destruction or dislocation, as in the case of the hip-joint.

**Shortening.**—Real shortening of a limb is due to actual bony destruction in some cases, but, in addition, there is usually some interference with growth at the epiphyseal line. Thus the difference in length of the two limbs may continue to increase after the disease has come to an end.

*Diagnosis.*—The persistence of swelling of the joint, limitation of movement, and muscular wasting are very suggestive of tuberculous disease. The diagnosis has to be made from other chronic joint diseases, such as chronic sprain, gonococcal arthritis, or hæmophilia, and in adults from monarticular osteo-arthritis. A good radiogram will often clear the matter up by showing characteristic bony changes.

Laboratory methods may be of use in doubtful cases. Cytological examination of the fluid obtained by puncture will, as a rule, show a predominance of lymphocytes. The direct search of films for the tubercle bacillus may fail, but inoculation of a guinea-pig is a certain means of establishing a correct diagnosis. The use of tuberculin as a means of diagnosis is not of great value. The general reaction of the patient is quite inconclusive, as there are usually other tuberculous foci in the body, but a local reaction in the joint has more value.

*Treatment.*—(*a*) *General.*—The raising of the patient's resistance to the tubercle bacillus by placing him under the best possible hygienic conditions is as important in tuberculous disease of the joints as it is in the pulmonary affections. Nourishing food, cod-liver oil, and abundance of fresh air and sunlight are the main indications. These are best obtained in a country hospital especially devoted to surgical tuberculosis, the most perfect example of which in this country is Treloar's Cripples' Home, at Alton. But even in a town a great deal can be done by allowing the patient to spend his days and nights in a small garden or on a balcony properly protected from rain and cold. The latter can be guarded against by adequate bed-clothes, mittens, hot-water bottles, or even by electrically-heated mattresses.

*Tuberculin and other vaccines.*—The treatment of tuberculous joints by injections of tuberculin, as an addition to other forms of treatment, has not proved of great value. It has been used both as a method of treatment and as a prophylactic, to prevent recurrence of the disease. Where sinuses exist with pyogenic infection, autogenous vaccines have a distinct field of usefulness.

(*b*) *Local treatment.*—The local treatment will be discussed in detail under individual joints. It consists in :—

1. Removal of deformity by weight extension or the application of successive plasters.

2. Fixation of the joint by some form of splint to prevent movement and secure rest.

3. Traction and relief from weight-bearing, to remove interosseous pressure.

Certain additional methods have been used, but should only be employed in conjunction with those detailed above. The best known are :—

*Hyperæmic congestion.*—Introduced in Liverpool by H. O. Thomas, many years ago, under the name of "damming" and reintroduced by Bier. It consists in causing passive congestion in the joint by an elastic bandage applied to the limb on the proximal side of the joint, sufficiently tightly to constrict the veins, but not the arteries. The pressure is maintained for half an hour a day to begin with, and the time of application gradually increased until the bandage is worn for six hours at a time. No pain should be caused by its use, and the pulse should not be obliterated.

*Exposure of the joint to sunlight.*—The exposure of the affected joint to strong sunlight until the skin is burnt to a deep mahogany colour (heliotherapy) is much used in certain countries. It has distinct value, especially in cases in which sinuses are present. The sinus is covered with a single layer of gauze to keep off dust and flies. The time of exposure is, at first, restricted to a few minutes daily, so that the skin may not become sore, but, when a deep pigmentation is established, the limb is exposed all day.

**Operative treatment.**—Treatment by operation becomes less and less necessary as successive improvements in conservative technique are evolved. In all cases conservative methods should be given a thorough trial before operation is considered. Operation is required more frequently in adults than in children, and gives much better results in the former.

*Treatment of abscesses.*—Abscesses will often be absorbed when the joint is efficiently immobilised. If they persist or enlarge, they should be *aspirated* through a needle of large bore (such as Gauvain's syringe) and injected with an iodoform emulsion. The track of the needle should pass through an inch or more of healthy tissue, and not directly into the most superficial part of the abscess, or a sinus may form ; repeated aspiration may be necessary (see p. 234). If aspiration fails, or if a sequestrum is shown to be present by X-rays, the abscess should be incised, the pus evacuated, and the walls of the cavity curetted. Any sequestrum present should be removed and the wound sutured without drainage. The collection of blood-stained fluid which usually follows should be aspirated in forty-eight hours. Drainage of a tuberculous abscess should be avoided, as it is impossible by the most careful dressing to prevent secondary infection.

*Treatment of sinuses.*—Sinuses will often heal after curetting and injection of bismuth paste, but in old-standing cases, especially those in which a sequestrum is present, further operation may be necessary.

*Partial arthrectomy*, or erasion of the joint, is a less severe operation than excision. The aim is to remove all the diseased synovial membrane and any diseased cartilage or bone without interfering with the epiphyseal line. It is performed chiefly in children, in order that the growth of the bone may not be affected, but is an operation of very limited usefulness, as cases suitable for it can usually be cured by conservative measures. The result of a successful operation is ankylosis by fibrous tissue.

*Excision* or resection of the joint (complete arthrectomy) consists in removing the articular ends of the bones with all the diseased synovial membrane. The epiphyseal lines are almost always damaged, and the growth of the bone in children affected. In children, also, firm synostosis rarely happens, so that bending at the line of union subsequently occurs. For these reasons,

excision is an operation to be deprecated in children under the age of fourteen or fifteen. In adults, on the other hand, the results of the operation are usually very satisfactory. The indications for the operation are: (1) in patients over the age of fifteen in whom conservative treatment has failed; (2) where large sequestra are present; (3) where septic sinuses lead down to diseased bone; (4) in some cases of ankylosis in a bad position, and (5) to secure a movable joint in the upper limb in cases of ankylosis.

*Amputation* is occasionally necessary in neglected cases, especially in adults, though many with septic sinuses and lardaceous disease will recover when proper conservative treatment is instituted.

VI. **Syphilitic arthritis.—In acquired syphilis** several varieties of arthritis are met with.

1. In the *secondary* stage there may be pain and stiffness without effusion in one or more joints (syphilitic arthralgia). The joints often become affected in succession (wandering pains). Later in the secondary stage a mild synovitis with effusion of moderate amount may attack one or more joints, often symmetrically. Usually the affection is painless and unaccompanied by heat, and the movements are unrestricted unless there is marked effusion. The latter often shows considerable variation from day to day.

2. In the *tertiary* stage the joints, especially the large ones, may be the seat of a gummatous synovitis. Gummata arise in the deeper layers of the synovial membrane and produce considerable thickening. To the naked eye the thickened synovial membrane resembles that of diffuse tuberculous disease but tends to be more nodular in character. In advanced cases the gummata may soften and ulcerate into the joint, and subsequently the articular cartilages may be involved. In some cases the joint may be secondarily involved from gummatous disease of the neighbouring soft parts.

*Clinically* there is little or no effusion or pain, the joint being enlarged by a solid, nodular thickening of the synovial membrane. The limitation of movement is not as great as would be expected from the enlargement of the joint. The differential diagnosis between gummatous disease, sarcoma and tubercle may be difficult. The nodular character of the swelling, the history of syphilis, a positive Wassermann's reaction and evidence of syphilitic periostitis of the neighbouring bones in radiograms, will enable a diagnosis to be made.

3. *Syphilitic osteo-arthritis* occurs also as a rare form during the tertiary stage. The ends of the bones become enlarged and the cartilages eroded. The patients complain of neuralgic pains, especially at night.

**In congenital syphilis.**—1. In young infants *syphilitic epiphysitis* (syphilitic osteochondritis) may occur. Not infrequently the epiphyses become separated by the syphilitic granulation tissue which develops in the epiphyseal line. Clinically the limb appears to be paralysed (syphilitic pseudo-paralysis of Parrot). There is slight swelling in the region of the epiphyseal line, and when separation of the epiphysis has occurred, a dull grating can be obtained. The joints usually remain unaffected unless secondary infection and suppuration occurs.

2. In older children a *symmetrical painless effusion* occurs in the larger joints, especially the knees (Clutton's joints). As the effusion is often slight in amount and painless, the condition is not infrequently overlooked, and is only discovered during the routine examination of a patient brought for some other manifestation of syphilis such as interstitial keratitis.

3. *Gummatous synovitis* may occur in children or young adults as in the acquired disease.

*Treatment.*—The general treatment is by antisyphilitic remedies (see p. 99). Local treatment consists in resting the joint by suitable splints or removable plaster cases and in the prevention of deformity in advanced cases. In the acquired forms and in infants the disease readily yields to treatment, but the congenital cases in older children are often extremely resistant.

VII. **Arthritis deformans.**—Under this heading are classed a variety of subacute or chronic inflammatory conditions leading to chronic degenerative changes in the joints. Many names have been given to the different varieties, such as rheumatic gout, rheumatoid arthritis, osteo-arthritis, etc., but the pathological changes in the joints are similar in character, though in one type the changes may be more marked in the bones and cartilages and in another in the soft tissues.

Clinically, cases of arthritis deformans fall into three groups: (1) Rheumatoid arthritis; (2) Osteo-arthritis; (3) Pulmonary osteo-arthropathy.

(1) **Rheumatoid arthritis** is an affection of the joints occurring most commonly in women between the ages of twenty and forty, though it may be seen in children. Many joints are affected, and the two sides of the body are usually involved symmetrically. The proximal inter-phalangeal joints are usually attacked first (the terminal ones escaping), and then the other joints of the upper limb. In the lower limb the hips are usually exempt.

Fig. 354.—Syphilitic arthritis of knee joint, showing gummatous changes in the synovial membrane.

The onset is accompanied with a rise of temperature and an effusion into the joints. As the fluid becomes absorbed the synovial membrane is found to be thickened and the ligaments relaxed, and a characteristic spongy sensation can be felt at the metacarpo-phalangeal joints when the ends of the bones are rubbed together, as if the surfaces were covered with wet wash leather. There is a peri-articular fusiform swelling of the joints. The ends of the bones may become less dense; but no osteophytes are formed, the stress of the disease falling on the soft structures of the joint. Muscular spasm, followed by atrophy, is well marked. Deformities arise from muscular spasm acting on a joint with softened ligaments and not from any alteration in the shape of the ends of the bones.

In acute cases, when all the joints are simultaneously affected, this condition may be reached in a few months, and a patient be left—with distorted fingers and rigid wrists, with knees and elbows flexed and feet flattened—a helpless cripple.

In children there may be glandular and splenic enlargements (Still's disease) in addition to the joint changes, and in adults there is often a similar, though less conspicuous, involvement of the lymphatic glands.

*Treatment.*—Every possible primary source of infection should be looked for. The joints should be treated locally by rest for the relief of pain and effusion and suitable measures taken to prevent or correct deformity. If an organism can be identified a vaccine may prove useful.

(2) **Osteo-arthritis.**—The term *osteo-arthritis* should be reserved for a distinct type of degenerative change which affects, in turn, all the component parts of the joint and is usually associated with, or a sequel to, a chronic inflammation of low-grade intensity. The pathological changes which occur are distinctive and follow a fairly definite course. It is, in the main, a disease of middle life or old age, affecting both sexes alike, sometimes attacking only one joint, at other times many joints at the same time. The disease is chronic from the first and not associated with general constitutional symptoms.

Fig. 355. — Chronic osteo-arthritis of the knee joint. The patella has been turned down. (St. Bartholomew's Hospital Museum.)

*Etiology.—Infection.*—In many cases a definite focus of infection, such as pyorrhœa, septic tonsils, infection of the accessory sinuses of the nose or genito-urinary infection, is present. It is possible that the joint changes may be due to circulating toxins rather than to actual infection of the joint. The organism concerned is usually the streptococcus, but sometimes the bacillus coli.

*Predisposing causes.*—Anything which leads to an alteration in the structure or function of a joint may be a factor in the incidence of the disease ; such are :—

1. *Cold and damp.*—Workers whose occupation exposes them to cold and damp, especially those past middle age and those living on an insufficient diet, are liable to the disease.

2. *Trauma.*—Osteo-arthritis may result after some gross trauma such as dislocation, but more frequently follows some chronic form of irritation such as a displaced semilunar cartilage, a loose body, or repeated hæmorrhages as in hæmophilia.

3. *Abnormal strain.*—Where the axis of the joint has been altered, as the result of an imperfectly reduced fracture of a long bone or from a deformity such as genu valgum, an abnormal strain is thrown on the joint, and osteo-arthritis often supervenes. Thus osteo-arthritis of the hip-joint not uncommonly follows fracture of the femur.

4. *Infective arthritis.*—An attack of infective arthritis, *e.g.*, due to the gonococcus, frequently leaves a damaged joint in which the changes of osteo-arthritis subsequently appear. Here it is the damage to the joint and not the infecting organism which is the predisposing factor.

5. *Changes in internal secretions.*—Osteo-arthritis is common in women about the time of the menopause, a time when not only is the internal secretion of the ovary altered but when symptoms of hypothyroidism are common. It is probable that enough stress has not been laid on the *rôle* of the internal secretions in many cases of chronic joint disease.

6. *Changes in the nervous system.*—In the neuropathic arthropathies (Charcot's joints, syringomyelia, etc.), the joint changes are essentially similar to those of osteo-arthritis (see p. 854).

7. *Old age.*—Osteo-arthritis is usually a disease of middle or advanced age. Here degenerative changes in the blood-vessels and changes in the internal secretions probably come into play. In many cases several of the above factors may be combined in the causation of the disease.

*Pathology.—Changes in the cartilages.*—The hyaline matrix becomes fibrillated, especially in the parts exposed to pressure, and the smooth surface becomes shaggy or velvety in appearance from the exposure of the ends of these fibrils. As the disease progresses the softened cartilage is worn away by the friction of the joint surfaces and the bone is exposed.

The cartilage cells proliferate and lose their orderly arrangement, and as they proliferate, are cast off into the joint cavity. At the edge, however, the synovial membrane, which slightly overlaps the margin of the articular cartilage, prevents their escape, and so they collect and give rise to irregular nodular outgrowths or "ecchondroses." These soon ossify and are known as "osteophytes," the rim of osteophytes around the articular margin giving rise to the thickening known clinically as "lipping." Such a nodular osteophyte is sometimes detached and forms one variety of loose body.

FIG. 356.—Chronic osteo-arthritis of the hip joint. (St. Bartholomew's Hospital Museum.)

*Changes in the bones.*—The bone exposed by the wearing away of the cartilage is gradually worn away. The surface becomes condensed, ivory-like or eburnated, while the subjacent cancellous tissue is rarefied. The bone is often worn away in parallel grooves, and the destruction may be so extreme that the whole articular head of the bone may disappear.

*Changes in the synovial membrane.*—The synovial membrane becomes more vascular, thicker and denser. The fringes and the normal villi thicken and hypertrophy, and give rise to a shaggy or villous appearance. The normal villi contain a few cartilage cells, and these may proliferate and form small pedunculated masses of cartilage which sometimes become ossified.

*Changes in the synovial fluid.*—The synovial fluid may be much increased in amount and turbid from the presence of extruded cells and their degeneration products. In some cases it is diminished in amount, thick and viscid.

*Changes in the ligaments.*—The ligaments become softened and degenerated. They are often ragged and frayed on the surface.

*Changes in the muscles and tendons.*—The muscles undergo fatty changes and atrophy. Tendons may soften and fibrillate.

*Symptoms and signs.*—The patient usually complains of a painful, stiff and creaking joint. Pain is a variable symptom and not a marked feature of the disease. The pain and stiffness are relieved in many cases by a moderate use of the joint, while excessive use increases both pain and stiffness.

On examination of the joint a characteristic creaking is felt and often heard. The ends of the bones may be found to be enlarged, and "lipping," due to osteophytes, may be felt at the margin of the articular surface. The hypertrophied fringes of the synovial membrane may also be felt. Effusion is usually absent or moderate in amount.

In contrast to rheumatoid arthritis, muscular wasting and muscular spasm are seldom marked features. Deformity in most instances results from alteration in the shape of the bones and not from muscular spasm. In osteo-arthritis of the hip, when the head of the femur becomes distorted, adduction follows, but flexion of the knee, so commonly met with in rheumatoid arthritis, is rare, the usual deformity being a genu valgum. Constitutional disturbances, sensory affections and trophic changes in the skin, pigmentation, etc., all noticeable features of rheumatoid arthritis, are rarely met with in osteo-arthritis.

FIG. 357.—Arthritis deformans. Photograph of the knee of a patient which has become deformed, especially by bony masses on the adjacent margins of the femur and tibia.

*Treatment.* — When the morbid anatomy of this disease is passed in review it is obvious that if treatment is to be effective it must be commenced in the early stages before the disease advances to the destruction of bone. A joint crippled by osteo-arthritis is crippled beyond repair, and treatment can then only be directed to the relief of symptoms and prevention of further deformity.

*General treatment.* — The usual sites of a chronic infection should be carefully examined. The teeth are most frequently at fault. It is not so much the cases of frank pyorrhœa as those of infection of the roots of the teeth which must be sought, and the latter can only be discovered by careful radiograms. All infected teeth should be removed. Chronic septic tonsils, infections of the nasal sinuses, etc., should be carefully treated. No restriction in diet is required as a rule, though in middle-aged women, who have increased in weight, carbohydrates should be restricted and thyroid extract given. Drugs have no curative influence, but guaiacum and sulphur (3—5 grains of each in cachets), iodide of potassium, aspirin, arsenic and iron are used for the relief of pain or to improve the general condition. The mineral waters of various spas at home and abroad are largely used both internally and in the form of baths and douches.

*Local treatment.*—The joints should not be kept at rest unless acutely painful. Massage to improve the nutrition of the muscles, and passive movements

and exercise to maintain and improve the mobility of the joints, are useful. Douching, vapour baths, radiant heat and hot air baths, ionisation and diathermy are all beneficial in some cases. Passive congestion by a Bier's bandage will often relieve pain in twenty-four hours.

In active cases involving the hip or knee, much benefit may follow rest in bed with weight extension.

*Operative treatment* is rarely required, but when loose bodies or hypertrophied fringes give rise to symptoms they should be removed. Occasionally osteophytes which are limiting movement may be removed with benefit. In old-standing cases of painful osteo-arthritis in the hip joint with fixed adduction good results may be obtained by Albee's open operation to produce bony ankylosis in a good position.

Manipulation under an anæsthetic to restore movement in a joint hampered by osteo-arthritis is inadvisable.

(3) **Pulmonary hypertrophic osteo-arthropathy.**—The connexion between clubbed or drumstick finger ends and lung disease was observed by Hippocrates (Hippocratic fingers). But further changes involving the skeleton have been described of late years, and new information has been obtained by examination with the X-rays. Various pulmonary affections—bronchiectasis, chronic empyema, chronic phthisis, and malignant disease of the pleura—produce changes in the bones, while congenital heart disease and rapid pulmonary tuberculosis merely cause enlargement of the soft parts from venous congestion.

FIG. 358. — Pulmonary hypertrophic osteo-arthropathy, showing new periosteal bone and erosions of the joint surfaces.

The chief signs of the disease are :—

1. *Clubbing of fingers and toes.*—The terminal phalanges are not themselves enlarged, but there is considerable hyperplasia of the soft parts. The nails are striated, large in proportion to the fingers, and shaped like watch glasses. As they grow they curve towards the finger pulp and resemble the beak of a parrot.

2. *Changes in the bones.*—The fingers and toes are increased in thickness by the deposit of new periosteal bone. The shafts of the metacarpals and metatarsals, the first and sometimes the second row of phalanges, and the lower ends of the bones of the forearms and legs are most frequently affected.

3. *Changes in the joints.*—Effusion takes place into many joints, especially the knee, ankle and wrist, with thickening of the synovial membrane and erosion of cartilages in some cases. There is a tendency to spinal kyphosis, a curve forming in the lower dorsal region. The new periosteal bone is at first cancellous, but becomes more and more dense ; there is eccentric atrophy, especially at the ends of the long bones.

The course of the disease depends on the primary affection. Usually the joints and clubbing rapidly improve *pari passu* with the lung condition, and new bone formed may be completely absorbed.

## (C.) Neuropathic Arthritis.

1. **Charcot's disease** (tabetic arthropathy).—In the majority of cases of Charcot's disease signs of tabes dorsalis are already present, but occasionally there is evidence of joint disease before any signs of tabes can be detected. For the signs and symptoms of tabes a text-book on medicine should be consulted. Injury is probably the exciting cause which determines the arthropathies of tabes, and it is noticeable that the joints which bear weight (the hip, knee, ankle and tarsal joints) are most often attacked, though the shoulder, elbow and wrist are occasionally involved. Though the original tabes is due to syphilis, the joint affections are not syphilitic, and typical Charcot's joints can be produced in animals by injury after division of the posterior nerve roots.

FIG. 359. — Charcot's disease affecting the knee joint. (St. Bartholomew's Hospital Museum.)

*Pathology.*—The changes in the joint resemble those in osteo-arthritis, but differ in their rapid onset and extent. In the *atrophic* variety the cartilages and ends of the bones undergo extensive destruction, the ligaments are softened and stretched, and there is considerable effusion into the joint cavity. Spontaneous dislocation is of common occurrence. In the *hypertrophic* variety the original destruction is followed by extensive formation of new bone which may lead to locking of the joint in certain positions. Loose bodies may be present.

*Symptoms and signs.*—The onset is often sudden and is characterised by a considerable and *painless effusion*, which subsides after a few days, and is followed by rapid destruction of the joint with much painless hypermobility. There is usually grating on movement, partly due to the irregularity of the articular surfaces and partly to the formation of loose bodies. The bones and muscles quickly atrophy, and spontaneous fractures (as well as dislocations) are by no means uncommon.

*Diagnosis.*—Apart from the classical signs of locomotor ataxia (loss of patellar reflex, Argyll Robertson pupil, Romberg's sign and lightning pains), the presence of a perforating ulcer of the foot may often be a key in the differentiation of an early Charcot's joint from one of osteo-arthritis. A Wassermann's reaction of the blood and cerebro-spinal fluid may assist the diagnosis in doubtful cases. The rapidity of onset, the painlessness and the extensive destruction of the joint usually make the diagnosis clear.

*Treatment.*—In the early stages treatment should be directed to limiting the destructive process by rest and relief from weight-bearing; the greater the

interosseous pressure, the more rapidly the articular surfaces are worn away. When the capsule is much distended the effusion should be aspirated with a view to limiting the stretching and subsequent atrophy of the ligaments. The joint should be supported by a moulded leather or celluloid splint, and in the case of the lower limb a Thomas's caliper splint should be worn to enable the patient to get about without allowing the weight of the body to act on the joint.

Excision and amputations should as a rule be avoided. Repair rarely takes place, and the results are disappointing.

2. **Arthropathy in syringomyelia.**—The large joints of the upper extremity are usually involved, and in about 80 per cent. of the cases either the shoulder or elbow suffers. Clinically, the joint lesions resemble those seen in tabes, and the same atrophic and hypertrophic forms are met with. As in tabes

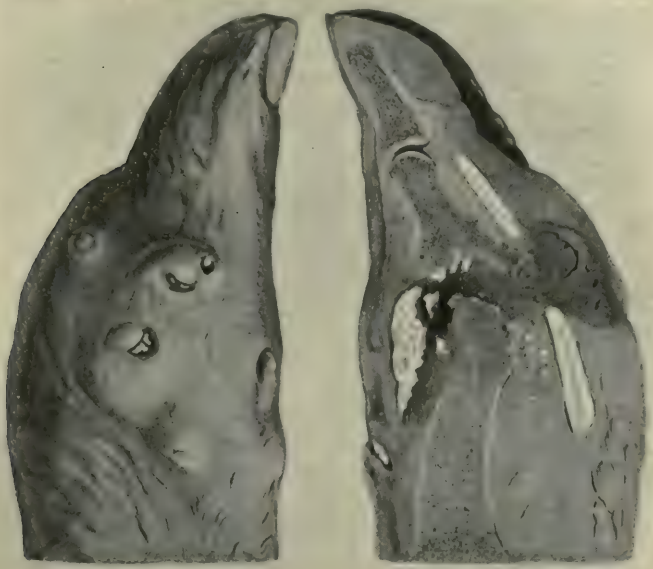


FIG. 360.—Gout of the metatarso-phalangeal joint of the great toe, showing suppuration with the formation of sinuses. (St. Bartholomew's Hospital Museum.)

also, spontaneous fractures and dislocations are not uncommon. Suppuration is liable to occur when there are trophic ulcers in the neighbourhood of the affected joint.

The diagnosis is made by recognising the characteristic signs of syringomyelia.

*Treatment.*—As for Charcot's joints, with the relief and prevention of septic conditions.

3. **Somewhat similar arthropathies** may occur after lesions of the peripheral nerves and in certain conditions of the central nervous system, *e.g.*, hemiplegia, paraplegia, anterior polio-myelitis, spina bifida, etc.

## (D.) Arthritis in Gout.

Gout is a disease of metabolism, which is of more importance to the physician than the surgeon. It has, however, to be diagnosed from essentially

surgical complaints, and may occasionally require surgical treatment. The gout changes are due to the deposition of crystals of biurate of soda in the articular cartilage and other structures of the joint. The metatarso-phalangeal joint of the great toe is especially liable to be attacked, though the larger joints, such as the knee, ankle or wrist, are not infrequently involved. The hip and shoulder usually escape.

*Symptoms and signs.*—In an acute "attack of gout" the great toe joint becomes hot and swollen, with tense, red and shiny skin over it. The joint is exquisitely painful, and the slightest movement is unbearable. The attack may last for a few days, or even for a fortnight or more, being worse at night. Such an acute attack may be initiated in a gouty subject by slight trauma, a sprained ankle, or a surgical operation on another part of the body.

After many attacks chronic changes resembling osteo-arthritis are set up. The cartilage is destroyed, osteophytes are formed, and great distortion occurs. When subcutaneous deposits of biurates or "tophi" are formed, ulceration of the overlying skin with consequent sepsis may follow and suppurative arthritis supervene. Amputation may have to be done for this condition, as the tissues of a gouty joint are in a condition of malnutrition and are unable to resist sepsis.

Incisions should not be made in tissues containing deposits of biurate, as they rarely heal.

The general treatment of gout must be sought in text-books of medicine.

### (E.) Arthritis in Hæmophilia.

In the subjects affected with hæmophilia hæmorrhage may occur in one or more of the joints, the large joints, especially the knee, being usually affected. The presence of blood excites an acute inflammatory reaction with the usual symptoms of pain, heat, swelling and limitation of movement. As the blood is very slowly absorbed, the synovial membrane may remain thickened by the formation of interstitial fibrous tissue. When several attacks of bleeding have occurred in the same joint chronic degenerative changes resembling osteo-arthritis are set up; the cartilages become fibrillated and eroded, and osteophytes form.

*Diagnosis.*— The condition occurs most often in children, and resembles tuberculosis rather closely. The diagnosis is made by the history of other bleedings and the sudden onset of the arthritis.

*Treatment.*—The joint should be immobilised during the acute attack, and should on no account be incised or even aspirated. Subcutaneous injections of normal blood serum, or a blood transfusion of small volume, will assist in raising the coagulability of the blood and arresting hæmorrhage if it has not ceased when the patient is seen. In recurring cases, protection of the joint from injury and weight-bearing may be obtained by wearing a Thomas's caliper splint. If fixed flexion is present it should be reduced by gradual weight extension, and never by forcible wrenching, as a new hæmorrhage is easily induced.

### Neuromimesis.

**Hysterical joint—Functional disease of joints.**—This is usually an affection of young girls, but males are not exempt. It occurs in men usually in connexion with some injury for which compensation is claimed, and, in common with other functional disorders, is not unusual in wounded soldiers. Young children and even the middle-aged are sometimes affected.

HÆMOPHILIC KNEE JOINT.

The thickened, brownish-stained synovial membrane and the small erosions of the articular cartilage are well shown. (St. Bartholomew's Hospital Museum.)

*Symptoms and signs.*—The joint condition is characterised by muscular contractures, and by functional defect without structural change. Alterations of sensation, often anæsthesia, sometimes hyperæsthesia, are present.

In a functional disorder of a joint pain is usually out of all proportion to the other signs of disease and not confined to the joint itself. The joint is often exquisitely tender to the slightest touch, but comparatively tolerant of firm pressure, or *vice versâ*. Swelling is seldom seen, and the joint is not only free from heat, but often colder than normal, though subject to occasional flushings.

Exaggerated stiffness and gross postural deformity are marked features of nervous mimicry. Frequently the limb is held, not in the position of greatest ease, but in the reverse. The position adopted may vary from time to time. Muscular wasting may occur in rare instances, but not to a degree corresponding to the severity of the supposed affection. Rigidity will always vanish under anæsthesia and sometimes during sleep. In moments of excitement the tenderness, which is usually so acute, will often disappear.

In long-standing cases genuine contractions may follow the long-continued deformity and wasting of muscles give an appearance of enlargement to the affected joint.

The fact that hysteria and genuine joint disease may co-exist must not be lost sight of, if mistakes in diagnosis are to be avoided In wounded soldiers especially it is necessary to separate the loss of function due to organic lesion from the superadded functional element.

*Treatment.*—All treatment has as its aim an effect on the mind of the patient. Recovery usually quickly follows treatment by suggestion and re-education of the contracted muscles. It may be aided by attention to the general health, massage and electro-therapy. The administration of an anæsthetic and the performance of a "pseudo-operation" is occasionally justified.

In some cases relapse follows, often in some other part of the body.

## Ankylosis of Joints and Stiff Joints.

The old classification into *true ankylosis*, due to tough intra-articular fibrous adhesions or direct union by bone, and *false ankylosis*, in which the disability is caused by extra-articular lesions, is not of great practical utility. In every case of persistent limitation of movement a very careful clinical examination should be made in the light of the previous history to determine the anatomical structures involved and the pathological conditions present. The examination is completed by radiography and in some cases by examination under an anæsthetic.

The causes may be classified as follows :—

1. *Contraction of scars of the skin* and deep fascia after an injury, such as a burn, or chronic ulcer.

2. *Contraction of muscles and tendons.*—After injury or inflammation of the belly of the muscle, in the groups opposing paralysed muscles, and in certain spastic conditions.

3. *Slight periarticular adhesions*, with slight limitation of movement and weakness of the joint, occur usually after slight injuries.

4. *Severe periarticular adhesions*, involving the soft structures outside the capsule of the joint, follow simple or compound fractures of the femur. They are often seen in cases where extension has been effected by calipers inserted in the condyles of the femur.

5. *Sclerosis of the joint capsule* and of the muscles about the joint with

adhesion of the muscles to the capsule.—This is usually the result of septic compound fractures.

6. *Alteration in the joint surfaces* by fracture extending into the joint or inflammatory erosion of the articular cartilages.

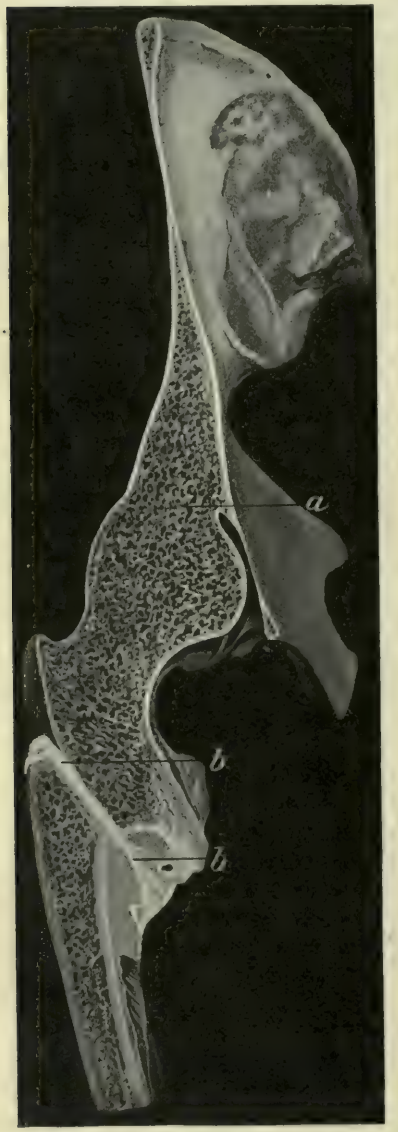



Fig. 361.—Ankylosis of hip joint. Subtrochanteric osteotomy. *a*, Bony ankylosis; *b b*, Fibrous union. (St. Bartholomew's Hospital Museum.)

7. *Obstruction by callus* after a fracture or by new bone formation in the muscles (myositis ossificans).

8. *Intra-articular fibrous ankylosis* of various degrees.—This is usually the result of previous infective arthritis, septic, gonococcal, tuberculous, etc., but may result from aseptic inflammation after injury, effusion of blood in the joint, etc. Intra-articular adhesions do not form in a joint as the result of prolonged immobilisation, with the exception of some cases where sepsis is present in the limb in the neighbourhood of the joint. Fibrous ankylosis may result after excision of a joint.

9. *Bony ankylosis* occurs after destruction of the articular cartilages by disease or operation. It is especially common after septic arthritis, but sometimes is the result of gonococcal or tuberculous inflammation, though the latter two infections more usually result in ankylosis by fibrous tissue. The formation of a bony ankylosis is the aim of many joint-excisions. It should only be diagnosed when there is complete absence of pain or movement on forcible attempts to move the joint, and even then the diagnosis may be wrong. The only absolute proof of bony union, short of inspection at operation, is the continuity of the cancellous lamellæ of the bones on either side of the line of union as shown in a radiogram.

*Treatment of stiff joints.*—The treatment of stiff joints requires more judgment than almost any other surgical problem. It is a department of surgery to which too little attention is often paid, with the result that patients drift from the medical practitioner to the bone-setter. Efficient treatment must depend on correct diagnosis of the actual pathological changes present and an appreciation of the aims with which treatment is instituted in the particular case under review. The characteristics of the various joints in their response to treatment must be kept in mind. Thus the

knee joint is tolerant of forcible movement, but the elbow is singularly intolerant, and such treatment often lessens instead of increases mobility. The objects of treatment are: in some cases to restore or, at any rate, to increase the range of movement; in other cases in which no restoration of movement is possible, but the joint is in a vicious posture, to place the limb in the most useful position; in yet other cases in which there is a small range of painful movement, to secure a stable and painless limb by bony ankylosis.

The methods of treatment are:—

1. *Rest.* When active inflammation is present rest by immobilisation should be instituted until the active stage has ceased. Myositis ossificans may be included under this heading. In the early stages the new bone will rapidly be absorbed. Later rest for a period of months will be necessary, and the final residue of bone may need excision.

2. *Movement under an anæsthetic*, the joint being put through its full range of movement and afterwards actively used. This treatment is very satisfactory in cases with slight peri- or intra-articular adhesions, which can be felt to give way as the joint is moved. The amount of force which may be used without the probability of an inflammatory reaction can only be judged by experience.

3. *Movement under an anæsthetic in successive stages.*—This is applicable to cases with more severe adhesions. The joint is moved sufficiently at each sitting to rupture some of the adhesions, but not enough to excite much inflammatory reaction. The second and subsequent anæsthetics are only given when the range of movement obtained at the first sitting has been retained.

4. *Forcible alteration of the position of a joint* and immobilisation in the new position.—This may be done in some cases of malposition, in which no useful range of movement is to be expected.

5. *Gradual alteration of the position of a joint* by weight extension, or by a rack splint or successive plaster of Paris cases.

6. *Physio-therapeutic methods.*—Baths, massage, gymnastic exercises and electro-therapy.

Hot water baths, melted paraffin baths, massage, ionisation, diathermy, X-rays and radium all have an action in softening fibrous adhesions and so rendering them more easily stretched by manipulation. Forcible passive movements by a masseur or gymnastic exercises which bring the patient's body weight to bear cause stretching of the adhesions. Electrical stimulation and active gymnastic exercises strengthen weak muscles and thus enable them to exercise an increased pull on the joint.

7. *Operative measures.*—(*a*) Operation on soft tissues: excision of scars, tenotomy or tendon lengthening, division of a sclerosed joint capsule.

(*b*) Excision of callus or bone which restricts movements.

(*c*) Osteotomy to correct malposition. Linear osteotomy is usually preferable to a removal of a wedge, as this always causes shortening.

(*d*) Excision of the joint. This may be done to correct malposition, to secure bony ankylosis, or in some cases to restore mobility.

(*e*) Arthroplasty, a formal operation to shape the ends of the bones, and interpose a flap of fat or fascia with the aim of securing a movable but stable joint.

In the case of the knee, ankle, shoulder and wrist joints stability is of more importance than movement, so that bony ankylosis in a good position is usually sought.

## New Growths of Joints.

It is a very uncommon event for a new growth to arise from the synovial membrane. Several varieties have been recorded.

1. **Lipoma.**—A subsynovial lipoma usually appears as a pedunculated mass projecting into the joint cavity. It may give rise to symptoms of loose body. The treatment is removal by arthrotomy.

2. **Chondroma.**—Masses of cartilage, usually multiple, may occur in the synovial membrane arising from the cartilage cells normally present in the synovial villi. They give rise to symptoms of loose body and should be removed.

3. **Angioma** has been recorded.

4. **Sarcoma.**—Primary sarcoma sometimes occurs, and has to be diagnosed from tuberculous and gummatous arthritis. The treatment is amputation.

Sarcoma of the ends of the bone may extend to the neighbouring joint, and rarely metastatic deposits of carcinoma may occur.

## Diseases of Special Joints.

### The Sacro-iliac Joint.

The sacro-iliac joint is rarely affected by disease other than tuberculosis, but it is occasionally the seat of suppurative arthritis in pyæmia.

**Tuberculous disease** is rare in childhood, occurring usually in young adult life. Owing to the depth of the joint and its covering by strong ligaments, local signs of inflammation are late in appearing. Abscesses may form and track (1) backwards over the joint; (2) forwards into the iliac fossa and then through the sacro-sciatic notch into the gluteal region; (3) along the sacrum and into the ischio-rectal fossa; (4) into the psoas or iliacus muscle.

*Symptoms and signs* are very variable and often lead to a diagnosis of disease of the lumbar spine or hip joint. The patient complains of a feeling of weakness in the lower part of the back, especially on standing or walking. Later definite pain is present which may be referred to the knee or down the thigh. The signs which may be observed are: (1) *pain* elicited by pressing the iliac crests together or apart; (2) *tenderness* over the joint; (3) *swelling* (*a*) over the joint, (*b*) in the iliac fossa, (*c*) felt per rectum; (4) *alteration in attitude:* the patient stands with the weight on the sound side, a compensatory scoliosis may be present, and in some cases there is abduction of the thigh with apparent lengthening of the lower limb; (5) *wasting* of muscles, especially the glutei.

*Diagnosis.*—The diagnosis must be made from disease of the lumbar spine and hip joint. Careful examination of these structures and of their range of movement will enable the distinction to be made. A radiogram is often useful.

*Treatment.*—In the early stages fixation by a plaster case from the axilla to knee and rest in bed may be tried. It is difficult to ensure adequate fixation of the joint, and the majority of cases progress in spite of this treatment.

*Operative treatment.*—(1) *Excision* of the joint through a curved posterior incision.—The object of the operation is to remove all diseased bone, cartilage and infected soft tissues. The wound is closed without drainage. Sinuses often result, and need successive operations.

(2) *Fixation* of the joint by an Albee's bone graft, taken from the crest of

the tibia, and inserted between the ilium and sacrum, has in some cases given good results, and seems to be an operation of promise for the future.

*Site for exploratory puncture.*—Between the posterior superior and posterior inferior iliac spines, the needle being directed forwards and outwards.

## The Hip Joint.

Tuberculosis and osteo-arthritis are the commonest diseases which attack the hip, but gonococcal arthritis is not infrequent. Suppurative arthritis occurs most commonly in infants, and in pyæmia. Sprain of the joint is very rare.

Swelling of the joint is shown by a fulness in Scarpa's triangle and by a lifting forward of the femoral artery, which becomes more evident to palpation than its fellow.

(i.) **Acute septic arthritis** usually occurs in the course of pyæmia.

*Symptoms.*—All the signs of an acute arthritis are present: raised temperature, pain, effusion in the joint, flexion, etc. The diagnosis can be confirmed by exploratory puncture. If not relieved by operation pathological dislocation is very liable to occur.

*Treatment.*—If diagnosed early the joint should be incised from in front, washed out, sutured, and a weight extension applied. If suppuration has occurred it is necessary to drain the joint from the front with counter-drainage from behind, and continuous irrigation or Carrel's treatment may be useful. If the acute symptoms persist more efficient drainage can be obtained by excising the head of the femur.

(ii.) **Acute arthritis of infants.**—This disease is not uncommon in children under the age of two. It is generally secondary to a focus in the head or neck of the femur. The infant at first keeps its limb in a position of flexion, and screams when it is touched. The joint rapidly becomes swollen and the child acutely ill. Diagnosis can be completed by puncture of the joint.

*Treatment.*—The joint must be incised at the earliest possible moment and drainage instituted. If this is delayed, the pus bursts from the joint into the surrounding tissues, and the upper end of the femur and acetabulum become necrosed, so that a flail joint results even if the child recovers from its exceedingly grave illness. As the disease so often begins in the head or neck of the femur, excision should be resorted to early, as a life-saving operation, if simple drainage does not speedily bring down the temperature, especially if this is of the " spiking " type with rigors or convulsions. Extension in the abducted position should then be instituted, and later the limb fixed in abduction in a plaster case with " windows " for dressing the wounds.

(iii.) **Tuberculous disease.**—The onset of tuberculous disease of the hip joint is usually insidious, and it is of the utmost importance that the disease should be recognised before the joint becomes disorganised. If the disease is recognised early and treated efficiently, a complete cure can often be effected.

The disease is most often met with in young children, and rarely commences after puberty. In some instances there is a history of recent injury which may lead to an error of diagnosis.

The tuberculous process begins near the epiphyseal line of the femur or in the acetabulum, occasionally in the synovial membrane. Wherever it arises, it soon involves all the structures of the joint. Bony sequestra are not commonly formed, but, if present, are usually small and cancellous; in rare cases the head of the femur becomes detached and lies loose in the joint cavity as a sequestrum. The upper and posterior part of the acetabular rim

is sometimes absorbed, and the remains of the head and neck displaced upwards and backwards on the dorsum ilii; here a new rim is formed by the periosteum, so that the acetabulum appears to have travelled upwards (wandering acetabulum).

*Symptoms and signs.*—In the early stage of the disease the signs differ somewhat from those seen in the later stages. Usually the earliest is a slight limp or an occasional ache in the region of the joint, or pain referred along the geniculate branch of the obturator nerve to the knee joint. On examination slight limitation of movement will be detected, but this sign may be absent after a day or two's rest in bed. Slight wasting or flabbiness of the muscles of the thigh or buttock will be found. The diagnosis in this stage may be extremely difficult, but if it can be made and treatment started early the results obtained are excellent. At a little later stage the signs are :—

1. *Wasting of muscles.*—The muscles of the thigh are diminished in size as compared with those of the sound side, the circumference as taken by a tape measure showing from ½ inch to 1½ inches difference. The calf muscles are wasted, but not to the same degree. The muscles of the buttock also suffer, and the gluteal fold is obliterated. To palpation the muscles appear flabby owing to loss of tone.

2. *Limitation of movement.*—A protective muscular spasm causes limitation of movement, especially of extension, adduction and internal rotation. Flexion is also impaired, but to a less degree.

3. *Malposition.*—The limb is flexed, abducted and rotated outwards at the hip joint. In order to compensate for the flexion, the child inclines the pelvis forwards by a compensatory *lordosis* of the lumbar spine; to overcome the abduction, the legs are brought parallel by tilting the pelvis downwards on the affected side, so that there is *apparent lengthening* of the limb (Fig. 363).

4. *Swelling* is of less importance in the hip than in other joints. A fulness in Scarpa's triangle may be detected, and the femoral artery, which is pushed forwards, may be felt more distinctly than its fellow. The inguinal lymphatic glands may be palpably enlarged, and deep palpation above Poupart's ligament may reveal enlarged iliac glands.

5. *Pain* is more frequently experienced in the knee than in the hip itself, but is felt in the hip joint on attempted movement and on pressing the head of the femur upwards into the acetabulum.

At a later stage, when destruction of cartilage has commenced, nocturnal starting pains occur. These are due to the relaxation of the protective muscular spasm during deep sleep allowing some movement in the inflamed joint. A sudden reflex contraction of the muscles occurs, crowding together the inflamed surfaces, and the pain causes the child to wake up with a sudden cry. In this stage wasting of muscles is more pronounced. The limb assumes a new position of flexion, adduction and internal rotation. The flexion is, as before, compensated by lordosis, and to overcome the adduction the pelvis is tilted up on the affected side (Fig. 363), causing *apparent shortening* of the limb.

In a still later stage, where actual destruction of bone has occurred, there is *true shortening* of the limb. This may be due to (1) destruction of the head of the femur, (2) erosion of the acetabulum, (3) dislocation upwards of the head of the femur, or (4) diminished growth of the femur.

The temperature is usually raised during the active stages of the disease, especially in the evening.

*Abscess.*—When hip disease is treated early suppuration does not occur in more than 10 per cent. of the cases, but if the disease is allowed to advance

untreated, caseation and suppuration are to be expected. The most serious cases are those in which abscess, accompanied by persistent rise of temperature, occurs early in the disease. An abscess may point in Scarpa's triangle, in the gluteal region on the inner side of the great trochanter, or it may pass through the acetabulum into the pelvis and burst into one of the hollow viscera, rectum, vagina or bladder, or even pass into the ischio-rectal fossa. If the abscess is allowed to burst it becomes secondarily infected with pyogenic organisms, and a persistent sinus forms. The temperature becomes of the "septic" type, and lardaceous disease may later supervene.

*Double hip disease* does occur, though one hip is usually affected before the other; the cases tend to be of a severe type.

*Examination.*—Children should be completely stripped, and older patients should remove all clothes below the waist, so that both lower limbs and the pelvis are exposed for examination. The patient should be recumbent on a hard couch or table.

The sound limb should first be put gently through its full range of movement, flexion, extension, abduction, adduction and rotation being examined in turn. In this way the patient's confidence is gained and the surgeon discovers the normal range of movement. The suspected joint is then examined in the same way. The movements should be tested in the above order, which is the opposite to that in which they are affected, rotation being affected first and flexion last. Loss of extension is determined by laying the patient on the face and lifting the thigh upwards. Loss of movement should always be recorded in degrees.

The degree of fixed deformity should next be examined. Flexion is best discovered by flexing the sound limb until the knee touches the chest; this abolishes the lordosis, and flexion of the affected limb is at once revealed (see Fig. 362). Adduction and abduction are discovered by noting whether the anterior superior iliac spines are on the same level when the legs are parallel. If there is tilting of the pelvis up or down this must be corrected, when the abduction or adduction deformity will be apparent. Apparent lengthening or shortening can be measured by running a tape measure from the umbilicus to the tip of the internal malleolus on both sides, true shortening by measuring from the tip of the malleolus to the anterior superior iliac spine. It can be confirmed by the relation of the upper border of the great trochanter to Nelaton's line or by Bryant's triangle (p. 531).

Loss of tone and wasting of the muscles should next be observed and measurements taken with the tape on both sides at equal distances from a fixed point such as the upper margin of the patella.

Any swelling in the region of the joint should be sought for by grasping the joint between the finger and thumb in a direction from before backwards.

A radiogram should always be taken of both hips. Negative X-ray evidence is of no value, but evidence of some other condition than tubercle may be obtained.

*Diagnosis* (see also Section III., p. 250).—Tuberculous disease of the hip has to be diagnosed from:—

1. *Other inflammatory conditions of the hip joint.* In acute infections the high temperature, greater swelling, leucocytosis and character of the fluid obtained by aspiration will enable the distinction to be made; in traumatic inflammations the diagnosis is often in doubt at first.

2. *Tuberculous disease of the lumbar spine*, with psoas abscess, may cause flexion of the hip and limitation of movement. Examination of the spine and X-ray evidence will enable a correct diagnosis to be made.

3. *Arthritis deformans.*—A monarticular form of this disease is very rare in children, and the detection of disease in other joints will clear up the diagnosis.

4. *Coxa vara.*—Loss of external rotation and abduction with shortening. Radiogram is decisive.

5. *Congenital dislocation.*—Painless, often reducible (telescoping; radiogram).

6. *Calvé's pseudocoxalgia.*—Pain, limitation of movement and shortening Radiogram shows typical flattening of the epiphysis and fragmentation of the bony nucleus of the femoral head.

7. *Appendicitis* occasionally causes flexion from contraction of the psoas muscle.

8. *Tuberculous disease of knee joint.*

*Prognosis.*—The prognosis as to life in children is good, as even when lardaceous disease has occurred prolonged treatment often brings about a cure. Complete recovery of movement of the joint is rarely obtained, and varying degrees of fibrous ankylosis are the rule. The limb is almost always shortened, and the shortening may increase after cure of the disease owing to diminished growth of the limb.

In adults the prognosis is much graver both as regards function and life.

Recrudescence of the disease occurs in some cases long after an apparent cure.

*Treatment.*—The principles of treatment of tuberculous hip disease are those of tuberculous joint disease in general, viz., rest, extension and reduction of deformity.

1. *Treatment by weight extension.*—The patient lies in bed on a firm mattress with boards beneath it, a small pillow only being allowed in order that the body may be horizontal. To ensure the maintenance of the horizontal position a Liston's long splint, reaching from the axilla to below the foot, is bandaged to the *sound* side, and a broad webbing strap is passed loosely around the chest and under the bed.

A strip of adhesive strapping, two or three inches wide, is applied from well above the knee to below the foot on either side of the affected limb. A few narrow strips are placed obliquely round the limb, and a bandage over all. The lower ends are fastened to a piece of wood, the "stirrup," which should be wider than the distance between the malleoli, so that the latter sustain no pressure. Through a hole in the stirrup passes a piece of cord, which runs over a pulley wheel and to which is fastened the weight. The strapping extends above the knee in order that the weight shall not unduly stretch the ligaments of the knee. The weight should not be put on for several hours, as the strapping requires time to become firmly adherent.

In order to avoid interosseous pressure between the head of the femur and the acetabulum it is essential that the pull of the cord should be exactly in line with the limb in its deformed position. The thigh is therefore raised until the back is flat upon the mattress and all lordosis has disappeared, and abducted or adducted until the anterior superior iliac spines are on the same level. The limb is then supported by pillows or a padded wooden frame in this position, and the pulley adjusted so that the cord is pulling in a line with the long axis of the femur. The amount of weight varies with the age of the child; in children under ten from 3 to 5 pounds is usually sufficient. If this weight does not abolish night cries it must be gradually increased. Too heavy weights are injurious and cause undue stretching of ligaments.

As the muscular spasm relaxes under the continuous extension the position of the limb is gradually altered until it lies parallel to its fellow without

producing either lordosis or tilting of the pelvis. At this stage it may be necessary to deal with eversion by applying a short back splint with a foot piece at right angles. This is at first kept in the deformed position by sandbags and gradually lowered.

A certain amount of abduction is an advantage, as it compensates for shortening, but where adduction is present and is difficult to overcome, it may be necessary to have recourse to lateral traction on the thigh by means of a webbing strap and a weight extension acting at right angles to the long axis of the thigh.

2. *Treatment by successive plaster cases.*—Some surgeons obtain the same result by applying a plaster case from the axilla and including the leg and foot. The muscular spasm diminishes by the enforced rest, and at the end of a few weeks the case is removed and a new one applied with the limb in a less deformed position. By successive plasters all deformity may be abolished Interosseous pressure is, however, not got rid of by this method.

FIG. 362.—Method of examination for fixed flexion in tuberculous disease of the hip joint. (A photograph kindly lent by Mr. G. P. Newbolt.)

By whatever method the deformity is treated, the chlid must be kept recumbent for at least three months after all pain and muscular spasm has disappeared. The weight is then gradually diminished, and if it is found that pain and spasm do not recur a Thomas's splint may be fitted and the child allowed to get up.

3. *Treatment by Thomas's splint.*—Thomas's hip splint consists of a bar of iron which extends from the scapula to the mid-leg. It has a curve to fit the buttock, and the lower part is in a line which is parallel to the line of the upper part. Three bands of softer iron, which can be bent by the hands, are attached to it, one to go round the chest, one just below the buttock and one at the lower end round the calf. The splint is padded and covered with leather, and the ends of the cross-pieces are fitted with straps and buckles. A sling passes over the shoulder from the upper cross-band. It is best to bandage the lower limb to the splint. A patten 3 inches in height is placed on the boot of the sound side, and crutches are used. At first it is well to replace the weight extension at night. After wearing the splint for a year it may be gradually left off, at first at night only. A careful watch must be kept for any evidence of return of symptoms, the earliest of which will be return of muscular spasm and consequent limitation of movement. If this occurs the

splint must be replaced for another six months. The average duration of treatment is from eighteen months to three years or more.

*Treatment of abscesses.*—See p. 847.

*Operative treatment.*—1. *Excision of the hip* is rarely performed in these days, as treatment on conservative lines gives such excellent results. It may, however, be occasionally required in cases of extensive bone disease with suppurating sinuses. It is best performed through an anterior incision.

2. *Amputation at the hip joint* is also becoming a very rare event. In cases with extensive disease and sinuses in which prolonged conservative treatment fails to cause improvement, it is probably better to amputate than to risk the extensive dissection necessary to remove all the disease by excision.

*Treatment of deformity.*—The shortening may be compensated by wearing a high boot or cork under the heel. It is rarely advisable to correct the whole of the shortening, as the patient is likely to catch the toe in walking.

Where recovery has taken place with fixed flexion or adduction it is gene-

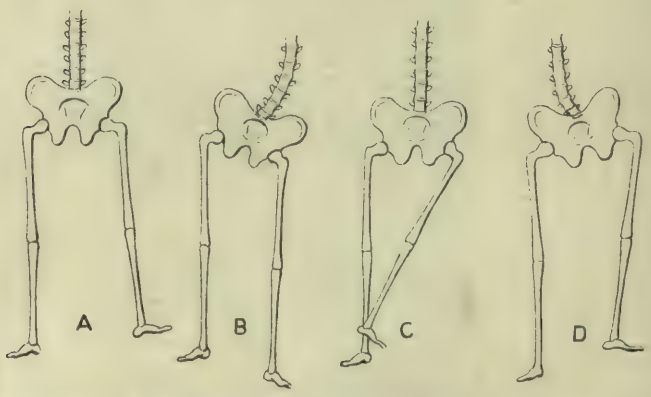



FIG. 363.—To show the effects of abduction (A) and adduction (C) in causing apparent lengthening (B) and apparent shortening (D) of the limb in hip joint disease when the affected limb is placed parallel to the opposite limb.

rally advisable to perform a transtrochanteric osteotomy with, if necessary, tenotomy of the adductors; the limb is then fixed in a plaster case for six weeks in the corrected position. Abduction, unless excessive, is an advantage, as it compensates for the shortening and does not need correction.

(iv.) **Osteo-arthritis** is common in the hip joint both as a part of poly-articular disease and as a single affection. Owing to the destruction of the head of the femur and the rim of the acetabulum in advanced cases, there is often great shortening and deformity of the limb. Adduction and great impairment of movement are also common in the late stages.

*Treatment.*—The treatment is that of osteo-arthritis in general. In active disease with much pain after exercise, rest in bed with weight extension for a few weeks will often give great relief. In late cases with much adduction and pain, excision of the head of the femur or, better, arthrodesis of the joint after Albee's method with tenotomy of the adductors, if necessary, gives good results.

**Position for ankylosis.**—The most useful position is one of slight abduction, with the thigh extended and slightly externally rotated.

**Site for exploratory puncture.**—The joint is best punctured from in front,

between the sartorius and tensor fasciæ femoris muscles. If this site is occupied by a superficial wound the needle can be passed along the neck of the femur from just behind the tip of the great trochanter.

## The Knee Joint.

The knee joint, probably because it is more exposed to injury, is more commonly affected by disease than any other joint. Effusion into the joint causes first obliteration of the normal fossæ on either side of the patella and of the groove above it and then swelling in the same situations. The patella is pushed forwards, and when pressed upon, is felt to tap against the condyles of the femur (riding patella). If the amount of fluid is small, this sign can be elicited by grasping the thigh just above the joint and so pressing the fluid from the subcrural pouch in the lower half of the articulation.

**Tuberculous disease** occurs most frequently in children, but adults of any age are not exempt. It may begin in the bones or in the synovial membrane, the latter being the most favourable type. The onset is usually insidious; slight stiffness and limping with little pain is all that is noticed in the early stages.

*Symptoms and signs.—Swelling.*—The characteristic doughy swelling of a tuberculous joint is best seen in the knee. The swelling is usually entirely due to pulpy thickening of the synovial membrane, and fluctuation is not obtained. The skin often becomes anæmic from the pressure of the swelling, and hence the term " white swelling " or " tumor albus " is applied to the condition.

*Limitation of movement.*—Reflex spasm of the strong hamstrings causes limitation of extension. Flexion remains unaffected until later.

*Muscular wasting*, both of the thigh and calf, occurs very early and rapidly increases. This atrophy of the muscles often causes the swelling of the joint to appear greater than it really is.

*Malposition.*—The leg is flexed upon the thigh by the action of the hamstrings. In untreated cases, a subluxation backwards of the tibia on the femur occurs, and the leg is externally rotated. This is the classical " triple displacement " of the knee joint. In addition, at a late stage abduction may occur, giving rise to knock-knee.

*Pain* is very variable. It is located in the joint and in general is not severe. In children, night cries may occur.

*Heat.*—While the disease is active surface heat is usually increased.

*Shortening.*—In the early stages the limb is not shortened and may even be longer than the opposite one, owing to stimulation of growth by increased vascularity. Later growth is affected, and shortening occurs.

*Diagnosis.*—The condition must be diagnosed from chronic synovitis, hæmophilia, and periarticular disease.

*Prognosis.*—The prognosis in a case which has received early treatment is excellent, many patients recovering with good movement. In later cases recovery with limitation of movement or complete ankylosis is the rule. In adults, the prognosis is less favourable, and conservative treatment often fails.

*Treatment.*—The usual general treatment of fresh air and good food is carried out.

*Local treatment.*—1. *Reduction of deformity.*—If there is any fixed flexion this must be reduced by weight extension applied, as in the case of the hip joint, in the line of the deformity. The strapping should extend as high as

the tubercle of the tibia and the leg be elevated on an inclined plane which is gradually lowered as the deformity is reduced; three to five pounds are usually enough in the case of a child. Counter-extension is produced by the weight of the body if the foot of the bed is raised on blocks.

An alternative method is to reduce the flexion by the application of successive plaster cases at intervals of a month until the limb is quite straight.

2. *Fixation.*—When deformity is abolished the joint is best fixed by a plaster case extending from just above the malleoli to the top of the thigh. A shorter plaster than this is quite inefficient, and allows a good deal of movement at the knee. The plaster should be worn for nine months in a favourable case, and during the first few months the patient should be kept recumbent.

FIG. 364.—X-ray photograph after excision of the knee in a young woman. The femur and tibia are united by bone in a horizontal plane, whilst the long axis of the femur is in line with the long axis of the tibia.

3. *Ambulatory treatment.* — During the later months of fixation the patient is allowed to walk with crutches and a patten on the sound foot. Children are apt to put the foot of the diseased side to the ground, and it is better to replace the plaster by a Thomas's knee splint. This consists of an iron ring, well padded and covered with leather, set obliquely on two iron rods. The latter pass down the sides of the lower limb to end 4 inches beyond the foot in another iron ring, into which a piece of indiarubber is fixed to absorb shocks. The weight of the body is transmitted from the tuber ischii, which rests upon the ring, through the splint to the ground. The limb is fixed to the splint by broad straps of leather and webbing, and a webbing sling passes over the opposite shoulder. A patten on the other foot and crutches complete the outfit. Extension may be kept up, if desired, by attaching the cord from the stirrup to the lower end of the splint, but if extension is necessary it is better to keep the patient recumbent.

At a later stage a caliper splint may be worn (see p. 545, Fig. 212).

*Operative treatment.* In children, even if conservative measures do not succeed, operation should be delayed as long as possible, as the results of excision of the knee in a growing child are on the whole *very disappointing*. Apart from the immediate risk of interference with growth, the line of union of the bones is often soft, and the pull of the strong hamstrings produces subsequent bending at the site of ankylosis. Other deformities, such as knock-knee, genu recurvatum, and occasionally flail joints, also occur.

*Arthrectomy*, or erasion of the joint, consists in removal of the synovial membrane and possibly part of the articular cartilage. As it is impossible to remove the whole of the synovial membrane without dividing the crucial and lateral ligaments, a weak and unstable joint frequently results. The cases which are suitable for this operation will, as a rule, give better results by conservative treatment.

*Excision* consists in removing the articular ends of the bones as well as the whole of the diseased soft parts. It is frequently necessary in adults and occasionally in children. When performed in children the epiphyseal lines should be saved, as otherwise a very serious shortening of the limb occurs, the knee being the site of the greatest increase in length of the whole body. Ankylosis by bony union is the aim of the operation.

Indications for operation are—(1) failure of conservative treatment, especially in adults; (2) in some cases of ankylosis a faulty position. After the operation, especially in young people, a moulded leather splint with steel supports should be worn for eighteen months or even longer to prevent bending.

*Amputation* is rarely necessary, but may be required in intractable cases with continued sepsis.

*Treatment of ankylosis with deformity.*—If any movement can be obtained, the deformity can often be reduced by weight extension, and can be combined if necessary with excision. In cases of firm fibrous ankylosis excision of the joint both corrects the deformity and allows of bony union. When deformity is present after bony ankylosis an osteotomy of the femur just above the epiphyseal line may be done, or a wedge may be removed from the site of the joint with its base forwards. In any case great care is necessary afterwards to prevent the recurrence of deformity.

**Position for ankylosis.**—Ankylosis with the leg in line with the thigh on the whole gives the best results. There is a slight advantage in a few degrees of flexion, but there is great danger of this increasing after ankylosis has occurred.

**Site for exploratory puncture.**—The knee joint may be punctured on either side of the patella at its upper border. If the needle is introduced at the lower end of the patella it passes into the sub-patella pad of fat and not into the joint cavity.

## The Ankle Joint.

(i.) **Sprain.**—The ankle is more frequently sprained than any other joint. An effusion in the joint causes swelling on either side of the tendo Achillis behind and to a less extent under the extensor tendons on the dorsum of the foot. For treatment see p. 833. A useful form of strapping is shown in Fig. 365.

(ii.) **Acute suppurative arthritis** most frequently follows osteo-myelitis of the tibia. It may, however, be pyæmic in origin or be due to a wound of the joint. The usual signs of acute arthritis are present. The joint is a difficult one to drain efficiently, and, unless rapid improvement occurs, either

astragalectomy or a Syme's amputation is called for. On the whole, amputation is to be preferred, as the foot after astragalectomy for a suppurating ankle joint is not so useful as a Syme's stump.

(iii.) **Tuberculous disease** begins most often in the astragalus, the tibia and fibula coming next in order of frequency.

*Symptoms and signs.—Swelling.*—Most marked at the side of the tendo Achillis. *Altered position.*—The foot is held in plantar flexion, so that the patient walks on the toes with the heel raised. Inversion or eversion is rarely seen. *Muscular wasting.*—Most marked in the calf. *Limitation of movement.*—The middle range of movement is often free, and limitation is only observed towards the extreme range. *Pain and tenderness* may both be absent, and are rarely very marked. *Heat of the surface* can usually be detected.

*Diagnosis.*—From chronic sprain, disease of the tibia and of the synovial sheaths of the extensor tendons. A good radiogram is always essential to determine the extent of the bony disease.

*Treatment.*—Treatment should always be conservative in the first place.

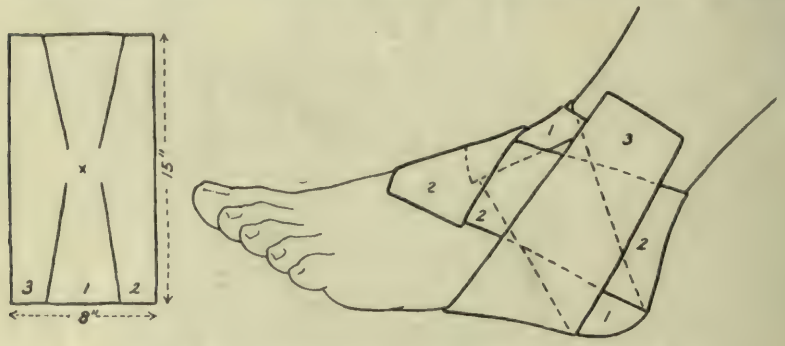



FIG. 365.—To show method of strapping the ankle joint.

Rest is best secured by the application of a plaster case, including the foot and extending above the knee. The foot should be placed at right angles to the leg and in a slightly varus position. If it cannot be placed in a correct position at first, successive plasters should be applied at intervals of a month. During the first few months the patient should be confined to bed, but afterwards he may be permitted to walk in a Thomas's knee splint with a patten on the other foot and crutches. The ankle should be fixed by a moulded leather or celluloid splint.

When conservative treatment fails, or in cases which come under observation at a late stage, operative treatment is necessary. *Excision* of the joint, usually with removal of the astragalus, gives a useful foot in the majority of cases. In some advanced cases *amputation* has to be performed.

**Position for ankylosis.**—The most useful position for ankylosis is with the foot at right angles to the leg and in a position of slight varus. Any tendency towards a valgus position must be avoided, as it results in a weak foot.

**Sites for exploratory puncture.**—(1) Behind the external malleolus, directing the needle inwards and forwards; (2) in front of the external malleolus, directing the needle inwards and backwards.

## The Shoulder Joint.

The shoulder joint is frequently the seat of osteo-arthritis; simple traumatic synovitis and tuberculosis are comparatively uncommon. Suppurative

arthritis occurs most often in the first few months of life. Swelling in this joint is not easily detected, unless of high degree, owing to the large muscles which surround the joint. It is seen first in the prolongation of the synovial membrane along the bicipital groove of the humerus, then in the axilla ; later the deltoid muscle becomes more prominent.

(i.) **Tuberculous disease.** Tuberculous disease occurs most commonly in children and young adults. It is usually of a very chronic type, and its onset is insidious ; the initial lesion is generally in the head of the humerus.

*Symptoms and signs.*—Pain is often absent, and when present may be referred to the insertion of the deltoid muscle. Limitation of movement and wasting of the deltoid and scapular muscles are the most prominent signs. Swelling is difficult to detect. Abscess is not common, but when it occurs, it may cause a fluctuating swelling beneath the deltoid, or it may point in the axilla or under the posterior edge of the deltoid. The head of the humerus may be cast off as a sequestrum.

*Diagnosis.*—The diagnosis from osteo-arthritis is not always easy, and may require radiography to clear the matter up.

*Prognosis.*—The disease is generally of a quiet, chronic type, and tends to recovery with ankylosis.

*Treatment.*—Rest by fixing the arm in the best position for ankylosis by means of a moulded leather shoulder cap and slinging the wrist. The weight of the arm replaces the weight extension necessary in the lower limb, and is sufficient to separate the joint surfaces when the muscular spasm is abolished by rest.

*Operative treatment.*—If conservative treatment fails, or if the head of the humerus is extensively diseased, in adults excision through an anterior incision gives excellent results, a movable joint often being obtained.

(ii.) **Osteo-arthritis.**—After the hip and knee the shoulder is the joint most commonly affected by osteo-arthritis. The symptoms have no special character, though pain is perhaps more frequently complained of than in other joints and may persist through the night and prevent the patient from sleeping. In advanced cases the head of the humerus and the glenoid fossa become greatly distorted, and there is great muscular wasting and limitation of movement. Treatment is on general lines. Where limitation of movement is due to adhesions round the joint, some good may be done by gently moving the joint under an anæsthetic, but much harm in those cases in which the intra-articular conditions are responsible for the stiffness. Where osteophytes are definitely restricting movement and it is probable that the articular cartilage is still present, their removal may be attempted.

**Position for ankylosis.**—The arm should be abducted to about 50° with the scapula in its normal position of rest; the elbows should be slightly in front of the coronal plane of the body. With the arm fixed in this position, it can be adducted and abducted by rotation of the scapula. In children in whom the movement of the scapula is freer and more hypertrophy of the scapular muscles may be expected, the degree of abduction is increased.

**Site for exploratory puncture.**—The joint is explored from the front. The needle passes through the lower border of the deltoid muscle, and not through the interspace between the deltoid and pectoralis major, in order to avoid the cephalic vein.

## The Elbow Joint.

Sprain is common in this joint, and tuberculosis, osteo-arthritis and suppurative arthritis are more frequent than in many other joints. Swelling

is evident on either side of the triceps tendon and on the outer side in the region of the head of the radius. The inflamed joint is held in a position of flexion and semi-pronation.

(i.) **Tuberculous disease** is common in children, though it may occur at any age.

*Symptoms and signs.*—The swelling at the sides of the triceps insertion is best observed from behind, when the width of the whole joint is seen to be increased. Restriction of movement is at first slight and limited to a loss of full extension. Later, with extension of the disease to the superior radio-ulnar joint, pronation and supination are affected. Pain is often absent, and is rarely of much importance. Muscular wasting is always present, and is most marked in the upper arm. As the disease extends the forearm tends to be held at an angle of about 140° with the upper arm, a disastrous position for ankylosis to occur in. If abscesses form they tend to point behind on either side of the triceps.

*Diagnosis.*—The diagnosis must be made from chronic sprain and syphilitic disease.

*Prognosis.*—If treatment is begun in the early stages a good prospect of recovery with free movement can be held out. Later, recovery with ankylosis is the rule.

*Treatment.*—Fixation with the forearm at an angle of 70° to the arm in a plaster of Paris case extending from just above the wrist to the insertion of the deltoid and support of the forearm in a sling is sufficient in the majority of cases. Later, the plaster may be superseded by a removable splint of moulded leather or celluloid. If the correct position cannot be secured at first, successive plasters should be applied at intervals of a month. Conservative treatment should be continued for long periods in childhood, even in cases in which sinuses are present, as excision of the joint does not give a very useful arm. In adults, however, excision may be resorted to much earlier, as it shortens the course of the disease considerably and a useful mobile joint is frequently secured.

(ii.) **Syphilitic disease.**—In congenital syphilis, the forms with effusion and gummatous disease both occur and are liable to be mistaken for tuberculosis. The presence of other signs of syphilis and a positive Wassermann reaction will enable a diagnosis to be made in a doubtful case.

(iii.) **Osteo-arthritis.**—In painful osteo-arthritis much relief may be obtained by the use of a moulded leather or celluloid splint to secure rest of the joint for a time.

**Position for ankylosis.**—The most useful position is fixation with the forearm at an angle of 70° with the arm, though for men in certain trades a larger angle may be more suitable. If both joints are affected one should be fixed at 70° and the other at 110°. The hand should be half-way between pronation and supination.

**Site for exploratory puncture.**—The joint is punctured from behind on either side of the tip of the olecranon or from the outer side above the head of the radius.

## The Wrist Joint.

Disease of the wrist joint proper rapidly involves the carpal and metacarpal joints, so that it is customary to include all these structures under the term wrist joint. Swelling is usually most marked posteriorly, where the extensor tendons are lifted up, and less on the palmar surface, but it may be seen here and on both sides, especially in the "anatomical snuff-box." Tuberculosis,

osteo-arthritis and gonococcal arthritis are the three commonest diseases. After the ankle, the wrist is the joint which is most frequently sprained.

(i.) **Tuberculous disease.**—Tuberculosis of the wrist is insidious in its onset and rarely painful. Limitation of movement may be slight until the disease is well established. Swelling and muscular wasting of the forearm, with the hand held in slight palmar flexion, are the early signs. The disease not infrequently supervenes after an injury, and as the early signs are slight, it may be overlooked and the disability attributed to chronic sprain.

*Prognosis.*—If treatment is begun in the early stages the results are excellent, and a movable joint is often secured. Unfortunately the diagnosis is often not made until the disease is well established, and extensive destruction of the carpal bones has occurred. In such a case the best that can be hoped for after long treatment is a fixed wrist.

*Treatment.*—The treatment is essentially conservative : fixation of the wrist in a position of dorsiflexion in a plaster of Paris or moulded leather splint. Even if sinuses are present conservative treatment should be persisted in for a long time and operation, if necessary, restricted to scraping away granulation tissue and removal of any carpal bone which has become a sequestrum. Excision of the carpal bones and wrist joint has occasionally to be performed, but the functional results are very poor. In the worst cases amputation may be necessary.

(ii.) **Osteo-arthritis** of the wrist is usually part of a polyarticular disease, and is resistant to treatment. If there is much pain after use, the joint should be kept at rest for a time in a splint.

(iii.) **Gonococcal arthritis** in the wrist joint is especially liable to lead to ankylosis. Massage and passive movements should be employed freely in the attempt to prevent this, but if ankylosis is likely to occur the hand must be placed in dorsiflexion.

**Position for ankylosis.**—The hand must be placed in marked dorsiflexion. In every case in which even limitation of movement is likely to occur, this must be attended to, as in palmar flexion the grip is so poor that the usefulness of the hand is very seriously diminished. It is not sufficient to place the forearm on a straight splint; actual dorsiflexion must in every case be obtained. If the inferior radio-ulnar joint is affected the hand should be placed midway between pronation and supination.

**Site for exploratory puncture.**—The joint is best punctured from behind.

# Section XX.

## GENERAL SURGERY OF THE ABDOMEN.

### Injuries and Diseases of the Abdominal Parietes.

### Injuries.

**Injuries of the abdomen** may be divided into :—

1. **Injuries of the abdominal walls without visceral complications :—**
   (*a*) Contusions.
   (*b*) Wounds.

2. **Injuries with visceral complications :—**
   (*a*) With rupturing of the viscera.
   (*b*) With wounding of the viscera.

#### 1. Injuries without Visceral Complications.

**Contusions.**—The simplest form of injury is a contusion which is indicated by the formation of an ecchymosis or of a hæmatoma, gives rise to temporary inconvenience only, and runs the course of a bruise as in any other part of the body. A muscle may be lacerated spontaneously and without external violence ; thus rupture of the rectus muscle may occur during parturition, gymnastic exercises, such as vaulting, or bowling at cricket, and also during the convulsions of tetanus and vomiting. More severe injury resulting from being run over, a crush, or violent blow on the abdomen, even when no internal viscus has been injured, is accompanied by a considerable amount of shock, especially when occurring in the neighbourhood of the solar plexus. The surgeon is called upon to determine—and determine quickly—whether the collapse of a patient is an indication of abdominal shock only or whether there are graver internal injuries to important viscera, such as the liver, spleen or intestine, accompanied with internal hæmorrhage—a question which is very often difficult to decide.

**Contusion of the parietal peritoneum** may occur from a blow or crush to the abdomen without injury to the viscera, and the special sign is localised pain. Complete repair of the peritoneum may take place, or adhesions form which may in time give rise to trouble or become absorbed.

**Wounds of the abdominal wall without visceral complications.**—Non-penetrating wounds are treated like wounds in other situations. It has to be remembered that they may be complicated by effusion of blood and suppuration in the subperitoneal tissue, and be followed by ventral hernia. Therefore they should be laid open sufficiently, and all dirt, foreign bodies, and crushed tissue removed. The muscles, if severed, should be sutured carefully, layer by layer, with catgut, this being preferable to silk on account of the liability to suppuration ; a ventral hernia is likely to follow on long-continued suppuration which may be kept up by a silk suture.

If the wound is clean-cut, it may be possible to close the skin entirely, but in lacerated wounds it is often wiser to leave the whole or a part open in order to allow of the escape of the products of inflammation and destruction of tissue. If this is not done and suppuration ensues, pus may spread far and wide between layers of muscle or under the skin, and give rise to great trouble.

**Penetrating wounds without visceral complications.**—Stab wounds and such like of the abdomen are treated by free exposure, because it is impossible to say at once whether the subjacent viscera are punctured or not. In any case, such a wound requires suturing to obviate the formation of a subsequent ventral hernia. Therefore it is advisable at the same time to enlarge the wound and, if necessary, open the abdomen sufficiently widely to explore the contents, and then suture the muscles layer by layer.

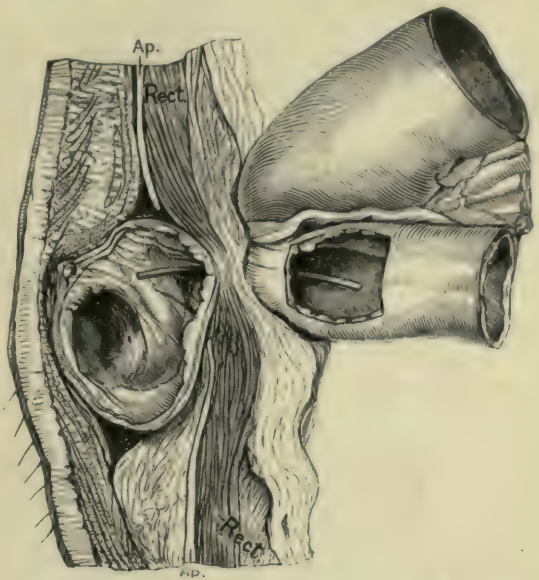



FIG. 366.—Traumatic hernia following a punctured wound of the abdomen. The wound healed by first intention, but four days after the injury a hernia appeared at its site and was reduced, but the reduction was incomplete, the gut having passed between the skin and sheath of the rectus and remained nipped at the opening through the sheath of the rectus. Ap., Aponeurosis. Rect., Rectus muscle. (St. Bartholomew's Hospital Museum.)

## 2. Injuries with Visceral Complications.

It is obvious that the abdominal walls are as a rule of minor significance in relation to abdominal injuries, the chief interest lying in the differential diagnosis between an injury of the parietes only and one that has affected the abnormal viscera as well. These organs are all of vital importance, though they are little liable to injury on account of their protected position and the ease with which they can slip away if pressed upon. Some of the viscera, such as the liver and spleen, are friable and vascular and, if wounded, bleed copiously, while a lesion of the intestines is liable to be followed by suppurative peritonitis.

(*a*) **With rupture of viscera.**—Rupture of viscera usually results from injury inflicted by a blunt object applied at right angles to the abdominal wall—for instance, a kick, the passage of a wheel across the abdomen, a crush between buffers, or a fall from a height on to some projecting object, such as a scaffold-pole. The degree of violence necessary to bring about a rupture varies very much according to the position of the patient, the preparedness to receive a blow, the strength of the abdominal muscles, and whether the viscera are distended or empty. A greater injury occurs when a blow falls quite unexpectedly on a patient of feeble muscular development in an erect position; while the hollow viscera, such as the stomach and bladder, are more

liable to be torn if distended rather than empty. The spleen or liver, if much enlarged, as in chronic malaria, may be lacerated by quite trifling violence.

Certain of the viscera are more liable to injury than others : the intestines slip away so easily that laceration is comparatively rare, though certain parts, especially the fixed portions, for instance the third part of the duodenum where it crosses the vertebral column, are more prone to injury. The liver and spleen are partly protected by the ribs, and are usually ruptured by some accident such as the passage of a wheel of a cart over the lower part of the chest. The pancreas is in a most protected position, and is rarely injured unless the violence is so great as to bring about immediate death.

There are numerous instances of blood-vessels being lacerated without external wound, the commonest being the vessels of the mesentery, and more rarely the vena cava, the aorta, and the portal vein or its tributaries.

These injuries are very fatal. The causes of death are, firstly, shock, and later, if the patient gets over this, hæmorrhage and subsequently peritonitis.

The general symptoms vary greatly ; they may be divided into three classes :—

(*a*) The first are those which are rather vaguely defined by the word "*shock*," which is the sequel of a sudden and violent injury to the peritoneum and abdominal viscera. It is shown by collapse of the patient, a small, frequent, running pulse, a low temperature, pallor, and cold sweat. At first the patient may be rendered unconscious, and then lies restless, moaning, and complaining often of terrible abdominal pain. Vomiting often occurs, and there may be the occasional involuntary passage of a motion or urine. Great thirst is generally complained of. The above symptoms may be met with as the result of a severe blow without actual injury to viscera, and if the patient is kept warm in bed will gradually and steadily subside. In the case, however, of visceral injury the two following groups of symptoms appear, chiefly according to whether a solid or a hollow viscus has been injured.

(*b*) Where hæmorrhage is the marked feature, the patient remains blanched and faint, and the pulse, instead of diminishing in rate, becomes more and more frequent, and restlessness increases. The abdominal walls probably remain flaccid, and percussion reveals an effusion into the peritoneal cavity. If the patient is turned over on the side, the dulness leaves the upper loin and becomes greatly increased in the lower, and if the hæmorrhage is not checked, either spontaneously or by operation, the patient may bleed to death.

(*c*) If it is a hollow viscus that has been injured, the most marked feature is that of commencing peritonitis ; the abdomen becomes rigid and distended, the pulse-rate rises, and vomiting continues. In such a case the severe symptoms are a little postponed, and the surgeon may be lulled into a false sense of security by a temporary recovery from the initial shock and the lapse of time that occurs before the signs of peritonitis set in.

*Treatment of abdominal injuries with rupture of viscera.*—Seeing that there is no absolute guide as to whether or not any viscus has been injured, the safest plan, when there is any reasonable cause for doubt, is to open the abdomen as soon as the worst of the initial shock has passed and explore the contents, dealing with the injury found.

*Rupture of liver.*—If possible the torn edges of the liver should be approximated by stout catgut sutures passed deeply through the substance of the organ and tied lightly so as to avoid cutting out. In cases of severe laceration suture may be impossible, either from the extent of the injury, its situation, or from the serious condition of the patient ; then the only resource left is

to plug the torn surfaces with broad strips of gauze, leaving the ends protruding from the abdominal wound.

*Rupture of the spleen.*—If the laceration is only slight, it may be dealt with by suture, but the spleen is very friable, and the stitches tend to cut out. If such is the case, the right thing to do is to ligature the splenic vessels and remove the spleen. It is quite useless to attempt to pack with strips of gauze, for, the spleen being movable, no pressure can be exerted on it.

*Laceration of the intestine.* In this event the injured portion must be sutured. If only a small hole is torn in one side, this may be turned in by Lembert sutures, while if the whole intestine is torn right across, an anastomosis has to be done either side to side or end to end.

*Laceration of the mesentery.*—Bleeding points must be picked up and tied and any rent closed, care being taken to leave no raw surface from which adhesions may form without peritoneal covering.

(*b*) **With wounding of the viscera.**—Penetrating wounds may be of almost every kind, though they mostly come under the category of stabs and gunshot wounds. The viscera usually injured are the mesentery and small intestine, and then the stomach, colon, liver, spleen, and urinary bladder; the kidney is rarely reached unless by a stab in the loin.

**Protrusion of viscera.**—If the injury to the abdominal walls is an extensive one the viscera may protrude, and the protruded portion may or may not be injured.

*Treatment.*—Whether there is evidence of injury to viscera or not, the treatment should be the same in any case. Any penetrating wound of the abdomen should be laid freely open, the abdominal contents inspected, bleeding points ligatured, and any punctured viscus sutured. This is the safe plan, for there is no infallible guide to a diagnosis of an internal injury, and though it is true that such an injury is commonly associated with considerable shock, it by no means follows invariably. Patients have been known to walk into hospital looking apparently well, only to die later from severe internal injuries; they might have been saved by a timely operation.

To sum up the treatment of ordinary wounds of the abdomen (other than gunshot wounds):—All penetrating wounds of the abdomen, whether associated with injury to the viscera or not, should be laid freely open, the abdominal contents examined, and the muscles sutured layer by layer. In the case of non-penetrating wounds with doubtful rupture of viscera, the abdomen should be opened with a view to making an accurate diagnosis. Non-penetrating wounds in which the muscles have been divided should also be laid freely open for the purpose of cleansing, suturing, and the avoidance of a subsequent ventral hernia.

**Gunshot wounds of the abdomen.**—Before the late war it was generally considered that facilities for operating in the field could not be sufficiently satisfactory to justify opening the abdomen. It was advised, therefore, that the expectant treatment should be adopted.

Experience during the late war has disproved this, and now it is the rule that, in the case of penetrating wounds, the abdomen should be opened at the earliest opportunity, and any injured viscus repaired.

(For details see special works on war surgery.)

## Inflammatory Affections of the Abdominal Parietes.

Inflammation of the abdominal walls may arise from infection of the skin or subcutaneous tissue, or by spread of infection from deep-seated organs. In

the former case no special mention is required, seeing that a cellulitis arising in this way does not differ from that in other regions of the body. In the latter, the causes may be divided into two groups according to whether the cellulitis is superficial or deep to the abdominal muscles :—

1. The commonest instance of cellulitis spreading from a deep-seated organ to the superficial part of the abdominal wall is that due to extravasation of urine resulting from a ruptured or ulcerated urethra, following injury or stricture. The inflammation, starting in the perineum and being prevented from descending into the thigh by the attachment of Scarpa's fascia to Poupart's ligament, spreads up on to the abdomen and may reach the level of the umbilicus or even of the axilla (see p. 1102).

2. In the second group the space affected is that lying between the peritoneum and the posterior aspect of the abdominal muscles, suppuration giving rise to a swelling, either unilateral or central, which may point and burst either on to the surface of the skin or into the peritoneal cavity.

The site of such an abscess may be the bones of the pelvis and vertebral column, the urinary bladder, the uterus and broad ligaments, or some portion of the intestines. An abscess from the pelvic bones, vertebral column, or hip joint after perforation of the acetabulum, usually gives rise to a swelling in one or other of the iliac fossæ ; suppuration extending from the uterus and broad ligaments (*parametric abscess*) may form a similar swelling. That which originates from the urinary bladder rises from behind the symphysis pubis and forms a spherical swelling in the space of Retzius, simulating a distended bladder. Passage of a catheter does not cause it to disappear.

Inflammation may spread also from the intestines to the abdominal wall in cases of malignant disease or of localised appendix abscess, or on those rare occasions when an abscess has been originated by perforation with some foreign body such as a fish-bone, rabbit-bone or pin, the general cavity of the peritoneum being shut off by adhesions.

*Treatment.*—The abscess must be opened and drained, and the cause sought for and dealt with.

**Tuberculous abscess** may originate in the vertebræ, ribs or intestine, and, burrowing its way forward, point in the abdominal wall.

**Actinomycosis of the abdominal wall** is met with as an extension from some portion of the intestinal tract, generally the cæcum. It forms a hard, well-defined inflammatory mass which may be mistaken for a gumma. The course of the disease is a slow one as a rule, the abscess eventually bursting, discharging its characteristic little yellow granules, and leaving one or more sinuses communicating with the interior of the bowel. In some instances the abscess appears to change its position on the abdominal wall, and is called on this account a "*wandering abscess.*"

## Tumours of the Abdominal Wall.

These may be innocent or malignant, though neither of them are of common occurrence.

**Innocent tumours** are lipomata and fibromata. Lipomata may arise in the subcutaneous fat of the abdominal wall or in the extraperitoneal tissue. In the latter form they may herniate through the aponeurosis of the linea alba and simulate a ventral hernia. Fibromata form slow-growing, painless tumours, which are commonly soft and fleshy, often pedunculated, and may attain a great size.

**Malignant tumours.**—The only form of primary tumour that is at all common is a fibro-sarcoma which commences in the muscle itself, in its fascial coverings, or in the aponeurosis of the abdominal wall. These tumours are as a rule hard, painless, and slow-growing, and if left untreated may attain a large size. Their degree of malignancy is not great, showing it commonly only by a local recurrence after removal, and rarely by dissemination. In the early stages this tumour has to be distinguished from a gumma of the abdominal wall and some intra-abdominal swelling which has become adherent to the anterior parietes.

The *treatment* consists in the free excision of the affected part together with some of the surrounding muscle or fascia. Recurrences should be treated in a similar way, and the help of X-rays solicited as a preventive measure.

Secondary sarcoma and carcinoma may occur in the form of subcutaneous nodules.

## Affections of the Umbilicus.

**Inflammation** is as a rule due to want of cleanliness, especially in stout persons. It may be followed by eczema intertrigo, ulceration, or even by the formation of a small abscess. After bursting of such an abscess a small mass of granulation tissue is left which may be mistaken for malignant disease.

**Umbilical fistulæ** may discharge urine, fæces, bile, or pus.

*Urinary fistulæ* are the result of a patent urachus or the reopening of a urachus in an infant in whom the lower urinary passages are obstructed by fibrosis or urethral calculus. If the fistula does not close spontaneously when the cause is removed, the urachus should be dissected out to its attachment to the bladder and the lower end inverted and sutured.

*Fæcal fistulæ* may be due to a persistent Meckel's diverticulum, to the bursting of a fæcal abscess resulting from tuberculous peritonitis, or to gangrene of the intestine in a strangulated umbilical hernia. A patent Meckel's diverticulum, when the intestine below it is pervious, may be resected, the lower end being inverted into the ileum and sutured. For fistulæ resulting from a broken-down tuberculous abscess very little can be done except by improving the general health of the patient, the matting of the intestines and involvement of the greater part of the abdominal cavity precluding radical cure by operation.

*Biliary fistulæ* are due to the extension of an abscess from the gall-bladder or bile-duct making its way forward.

*A fistula discharging pus* may be the result of an old tuberculous abscess or caused by suppuration tracking along the abdominal wall from an empyema or abscess in connexion with the intestinal tract.

## Tumours of the Umbilicus.

**Cysts.**—Apart from the sebaceous cyst which may occur at the umbilicus equally well as in any other part of the body, cysts may arise in the vestigial remains of the urachus or vitelline duct.

**Innocent tumours.**—These may be small lipomata or fibromata, and have no special significance.

**Malignant tumours.**—Primary tumours are very rare, but it is not unusual to find a small nodule of secondary carcinoma which has spread along the round ligament of the liver, and which may serve as a clue in the diagnosis of an unexplained swelling within the abdomen.

General Considerations concerning Abdominal Operations.

**Preparation of the patient.**—Before being submitted to an operation it is advisable that patients should be put to bed for one or two days if there is time available, so that the surroundings may not appear strange, and they may get used to lying in bed. The bowel should be well cleared out by a dose of castor oil followed by an enema early in the morning of the day of operation. Light, easily digested food may be taken up to five hours before. It is not necessary to starve the patient more than this, and in feeble old people and young children the omission of food tends to weaken them.

**Choice of anæsthetic.**—As a rule a general anæsthetic is preferred to a local or spinal injection, the two latter being reserved for those in whom there is some special indication against the employment of any general anæsthesia, namely, diabetes or some severe cardiac or pulmonary complication. Good relaxation of the muscles can be obtained by the use of chloroform or ether; the choice rests with the individual wishes of the surgeon and anæsthetist.

**Choice of abdominal incision.**—This is important, and needs some consideration, for on it may depend the ease with which an operation can be carried out. The first point to be aimed at is to have an opening through which the object of the operation can be reached and dealt with in the easiest possible way. The second is to make the incision of such a character that it can be firmly sutured afterwards and leave the patient with an unyielding abdominal wall and without the danger of the formation of a ventral hernia. For this reason the abdomen is opened as a rule through the linea alba, by displacing the rectus muscle laterally, or by splitting the muscle in the direction of its fibres. Cutting across muscles and division of nerves are to be avoided as much as possible. The advantage of an incision in the mid-line is that a long cut may be made with very little hæmorrhage, and a good exposure obtained. An incision splitting the fibres of the rectus muscle gives more bleeding, but it has the advantage that the scar is protected by a layer of muscle.

The question of the abdominal incision must not be allowed to interfere with the performance of the operation, and in cases in which a deep-seated organ, such as the common bile duct, has to be exposed it may be advisable to make a transverse incision through the oblique muscles. After such an incision, however, scrupulous care must be taken in suturing the muscles layer by layer.

**Technique within the abdomen.**—Before commencing an abdominal operation it should be made an invariable rule to count all the instruments, pads and swabs that are to be used, and these should all be re-counted before the abdomen is closed, in order to guard against the possibility of leaving one of them behind. Numerous instances have occurred in which a pair of forceps or a swab has been left within the abdomen and has caused the formation of abscesses and even death of the patient, for which the surgeon is held to blame.

Asepsis of a rigid character is required, and is preferred to antisepsis, because any chemical is bound to irritate the peritoneum to a greater or lesser degree; thus any lotions that may be required for irrigation purposes should be of warm sterile salt solution. If any of the abdominal viscera are pulled out of the wound, they should be protected from touching the margins of the skin incision by being packed round with gauze; it is nearly impossible to sterilise the depths of the skin, where there are always some organisms.

If any of the hollow viscera have to be opened in the course of the operation, the peritoneum is protected from contamination by sterilised swabs and plain

gauze pads, which are best used dry. In order to guard against such being left behind many surgeons use pads with a long piece of tape attached. Blood is irritating to the peritoneum, and should be prevented from escaping by gauze packing.

During the whole course of the operation great care should be taken in handling the viscera, in order to do as little damage as possible to the delicate peritoneum; rough handling causes abrasions, following which adhesions are apt to occur, and the patient subjected to unnecessary pain.

In addition, it must be remembered that the less the intestines are injured the smaller will be the chances of infection, even if organisms are introduced from without. If the peritoneum is torn or a raw stump left, as after excision of an ovarian cyst, a few stitches should be put in so as to bring the peritoneal coat over the injured or raw surface, with the idea of preventing adhesions. If a raw surface is left too large in area to be covered with peritoneum, it has been suggested that it should be smeared over with a thin layer of sterile vaseline. Experience has shown that this is of no value.

**Closure of the abdominal wall.**—A great advance has been made of late years in the efficient closure of the abdomen. Previously big stitches were used, which traversed at once all the layers of the wall, but it is now known that a much better and firmer union takes place if the various constituents are united layer to layer. Thus peritoneum should be sewn to peritoneum, fascia to fascia, muscle to muscle, sheath of muscle to sheath of muscle, and skin to skin. This should be carried out whether the incision is made through the linea alba or through one of the muscles, and most particularly when an incision is carried across the fibres of a muscle. As long as the aseptic technique of the operation is efficient, the sutures may be of continuous silk or cotton, but if there is some doubt as to the wound being infected, then it is safer to employ interrupted catgut stitches.

**After-treatment.**– The patient is put back to bed, lying either on the side or on the back, with a pillow under the knees to relax the abdominal muscles. If he has been well prepared before the operation, vomiting is not usually a troublesome feature, but if it occurs, a big drink of warm water with a small quantity of sodium bicarbonate added will enable the patient to wash out the stomach.

As soon as all vomiting has ceased small quantities of fluid nourishment, and soon after light food, may be given. It is found that there is no necessity now to starve patients, as was done a few years ago—in fact, they do not seem to suffer from wind and discomfort in the same way if they are given food rather early. Flatulence is one of the most distressing symptoms, especially when there has been much disturbance of the intestines, and causes great discomfort. It may be relieved by passing a rectal tube and by the use of enemata. Drugs such as strychnine and eserine sulphate, which act as stimulants to the intestinal musculature, are also useful. Small doses of purgatives, such as calomel in repeated half-grain doses, may be administered, but it is on the whole better to avoid them and place reliance on enemata.

After some abdominal operations, especially those about the lower part, difficulty may be experienced in voiding urine. In most instances this can be accomplished by rolling on to the side, as it is not necessary in the majority of cases to keep patients rigidly on their backs; the passage of a catheter should be avoided if possible.

**Complications after abdominal operations.**—Of the immediate complications hæmorrhage is the most important, and it must be remembered that it should not occur, as it is due to careless or inefficient ligature of a vessel.

When it does arise it is a source of serious danger, for the hæmorrhage is concealed within the abdomen, and it is only the serious condition of the patient, arising from a rapid loss of a large quantity of blood, that calls attention to the fact.

As soon as the condition is diagnosed, the abdomen must be opened and the bleeding point sought out and secured. This should be done under an anæsthetic with full aseptic precautions, because after a serious bleeding the patient is more likely to become infected than before, and the results may be serious.

*Shock* is liable to occur after an operation in which there has been considerable loss of blood and rough handling of the intestines. It is to be combated by the use of hot-water bottles, saline injections, either rectal or intravenous, and the use of stimulants.

*Peritonitis.*—This, a few years ago the bugbear of surgeons, is no longer a terror to them. The aseptic technique is so complete that in all ordinary operations one can be sure that it will not occur.

*Bronchitis and pneumonia* are not uncommon complications, especially in old, feeble patients and in young children. In some cases the cause appears to be exposure during the operation and in others the result of the anæsthetic. Ether, especially if given throughout a long operation, is more liable to give rise to lung complications, and hence some surgeons prefer to use chloroform, or gas and oxygen.

**Remote complications** are *intestinal obstruction*, arising as the result of adhesions due to the operation, and *ventral hernia* subsequent to inefficient closure of the abdominal wall.

*Renal insufficiency.*—Patients suffering from renal disease or diabetes are not good subjects for operation; therefore an examination of the urine should always be made beforehand, and though the presence of albumen or sugar in the urine is not an actual bar to any operative procedure, the attendant risks should be calculated.

## Injuries and Diseases of the Peritoneum, Omentum, and Mesentery.

### Peritoneum and Mesentery.

It is well-nigh impossible for the thin serous peritoneal lining of the abdomen to be injured or inflamed without the underlying organs which it invests being affected to a greater or less extent, and similarly it is almost impossible for the peritoneum to escape if any of the viscera are inflamed. Hence it will be understood that spontaneous idiopathic affections of the peritoneum are of rare occurrence, and it may seem inconsistent at first sight to devote a special part of this section to this subject; but, seeing its enormous importance to the surgeon, some separate consideration is given, it being clearly understood that affections of the peritoneum must not be neglected when dealing with the diseases of individual abdominal viscera.

**Surgical anatomy of the peritoneum.**—The peritoneum is a closed serous membrane which covers more or less completely all the viscera and lines the wall of the abdominal cavity. It differs from other serous sacs in its great size and its many complications. In contradistinction to the pleural and pericardial cavities, which contain one organ only, the peritoneum lines a cavity containing many organs, most of which have undergone changes of position during development, thus producing complications. On opening the abdomen the peritoneal sac is entered, and the inner surface is seen to present

a smooth, polished surface covering the viscera; it is called the *visceral peritoneum*, while that portion covering the abdominal wall is styled the *parietal peritoneum*. The peritoneal cavity is divided into two main pouches or sacs communicating through a narrow opening. The larger or anterior pouch is that entered on opening the abdominal cavity; a smaller pouch or lesser sac of the peritoneum lies behind the stomach and gastro-hepatic omentum, and communicates with the greater cavity through the foramen of Winslow, which lies just below and behind the portal fissure of the liver. The foramen of Winslow, as indeed the whole of the peritoneal sac, is only a potential cavity, the two surfaces being in contact unless separated by fluids or gas. The importance of the foramen to the surgeon lies in the fact that the communication between the two cavities may be closed by inflammatory adhesions, and an abscess formed in the lesser sac may thus become shut off from the general peritoneal cavity. An omentum denotes a fold of peritoneum connecting the stomach to other viscera; thus the great or gastro-colic omentum connects the stomach with the transverse colon, and forms for the intestines an apron-like covering very rich in lymphatics. The gastro-hepatic omentum connects it with the liver, and the gastro-splenic omentum with the spleen.

Any fold of peritoneum which attaches the intestine to the abdominal wall is termed a *mesentery*, and conveys the blood-vessels, nerves, and lymphatics to the intestine. Injury to this mesentery, therefore, may mean impairment of vitality of the bowel. The attachment of the mesentery of the small intestine is along an oblique line from the left side of the second lumbar vertebra to the right iliac fossa; hence dragging of the mesentery, such as may occur in a large hernia, may give rise to pain high up in the abdomen. In addition to the lesser sac of the peritoneum, there are a number of small pouches which are of interest to the surgeon owing to the possibility of a piece of bowel becoming caught and strangulated in them (*internal hernia*). These pouches are found about the cæcum, pelvic colon, and duodeno-jejunal flexure.

**Physiology of the peritoneum.**—It is important to realise the great power of the peritoneum to absorb and exude fluids. Fluids and soluble substances, as well as small solid bodies placed in the peritoneal cavity, are absorbed and passed into the lymphatic and vascular circulations with great rapidity. Large lymphatic stomata are found in the peritoneum covering the upper portion of the abdominal cavity, and there is free lymphatic communication between the pleura and peritoneum. It is believed, therefore, that absorption takes place more rapidly from the upper than the lower portions of the abdomen, and for that reason the half-sitting or "Fowler" position is recommended for patients suffering from septic peritonitis, so that septic fluids may gravitate to the lower part, and the likelihood of the carriage of bacteria and toxic products into the blood-stream is lessened. If it were not for the great resistance of the peritoneum and its great capacity for destroying bacteria, many more lives would be lost than at present.

**Reaction of the peritoneum to injury.**—After an injury to the peritoneum, whether traumatic, chemical, or the result of bacterial infection, there is a very rapid reaction: an exudate of fluid takes place, and the injured surface becomes coated with a layer of sticky lymph, which tends to glue portions of the intestine to one another or to the parietal peritoneum. Later, this tissue becomes organised and fibrous adhesions result. Such adhesions when formed tend to shut off the injured area and limit infection mechanically, so that permanent repair may be brought about. The fate of the fibrous adhesions thus formed varies; if the injury is only slight they may, with cessation of the exciting cause, become obliterated entirely, or they may remain permanent,

becoming, as will be seen later on, a source of pain from dragging on the peritoneum or a source of danger from strangulation of a portion of intestine. In the case of bacterial infection of the peritoneum the fate of the individual rests largely on the amount of infection, the virulence of the infecting organism, and the resistance of the patient. If the conditions are unfavourable and the peritoneum proves itself incapable of localisation and resisting the infection, inflammation is liable to spread over the whole surface of the abdominal cavity ; fluid is exuded from the peritoneum, and the whole abdomen becoming filled with pus, from which toxins and bacteria are absorbed and enter the blood-stream, a general infection ensues from which it is unlikely that the patient can recover.

### The Organisms commonly found in Peritonitis.

The organisms found in cases of peritonitis are very numerous ; the common ones are the colon bacillus, streptococci and staphylococci, pneumococci, the tubercle bacillus, and the gonococcus.

**Mode of infection of the peritoneum.**—Organisms may gain entry to the peritoneum in a variety of ways.

1. The commonest channel is by extension of inflammation from abdominal viscera, resulting from disease, ulceration or perforation. As common instances may be mentioned appendicitis, suppuration about the biliary passages, perforated gastric or typhoid ulcer, salpingitis or a breaking-down lymph gland.

2. Dissemination through the blood-stream. Participating in general blood infections, organisms may be lodged in the peritoneum and set up peritonitis. A good instance of this is the miliary tuberculosis of the peritoneum occurring in a case of generalised tuberculosis, or pneumococcal peritonitis, the organisms having reached the blood-stream *viâ* the respiratory organs.

3. Infection from without, as from wounds or following surgical operations. Since the enormous improvement that has followed the introduction of the aseptic technique peritonitis from these causes has become comparatively rare.

Infective peritonitis may be diffuse or localised. Any difference between the two conditions is one of degree, and not of kind, but as the clinical appearances are so distinct, a separate description will be given.

### Diffuse Infective Peritonitis.

**Clinical features of a typical case.**—In making an examination of a patient supposed to be suffering from peritonitis a careful history should be taken first to find out the exact time of onset of the trouble, its relation to the taking of food, and any history of previous illness bearing on the case. The earliest and most prominent symptom is pain in the abdomen, associated often with some collapse, and this pain in the early stages is often indistinguishable from colic. At its onset it may be localised according to the region of the inflammation ; thus in the case of a perforated appendix the pain will be felt first over that area, and similarly a perforated gastric ulcer gives rise to pain in the upper part of the abdomen : with spread of the inflammation pain becomes more diffuse, and is usually referred to the region of the umbilicus. In order to relax the abdominal muscles the patient lies with the knees drawn up, and the abdomen ceases to move with respiration, because movements are painful. Vomiting starts early, and may be a prominent symptom throughout the

illness. Hiccough is common, especially when the surface of the diaphragm is affected, and, taken in conjunction with others, is a sign of grave import as indicating wide dissemination of the inflammatory process. The temperature at the commencement of septic peritonitis is variable and unreliable as an indication of the severity of the disease. It rises generally to about 101° F., and may be even higher before death. On the other hand, the temperature following a perforation may fall, and only rise in the later stages. A falling temperature with a rising pulse-rate may be taken as a bad sign. The pulse-rate varies much. At the commencement it may show no change of rate, but with increasing peritonitis it rises slowly to 100 a minute, and then, if the condition does not improve, to 120 or even 140, while in extreme cases it becomes thin, wiry, and almost uncountable. With diminution and improvement of the illness the pulse-rate generally falls, and this is one of the conditions which indicate the progress of the disease and should be watched. The tongue becomes dry and furred as the salivary secretion diminishes, and crusts form on the lips and teeth. Great thirst is commonly complained of, and the urine is scanty and high-coloured, and often contains some albumen as a result of toxæmia. The facial expression of the patient changes very noticeably. The face becomes pale, drawn and anxious-looking, and in the later stages assumes what is termed the "facies hippocratica."

*The abdomen.*—The patient should be examined in a good light and the whole of the abdomen and lower part of the chest exposed, so that respiratory movements may be observed before palpation is begun.

Movements of the abdomen cause pain if the peritoneum is inflamed, and in consequence the abdominal wall is held rigidly, and the ordinary respiratory movements do not take place or are not so free in character, respiration becoming costal in type. If the inflammation is limited to one side of the abdomen it may be that loss of movement is restricted to that side only, and this is often the case in early peritonitis, but in diffuse general inflammation the whole of the abdomen is held rigidly.

*Distension* is an early sign which appears as a result of loss of peristaltic power of the intestine and accumulation of gases. In a case that is progressing fast distension is a valuable sign and is a point to be noted, any increase being of grave import. Previous to paralytic distension there may be a period of increased peristalsis due to stimulation by the irritating influence of the inflammation, and this stage is indicated by acute colicky pains.

*Palpation.*—The hand should be passed lightly over the abdomen so as to gauge the amount of rigidity and to find out whether this is more marked on one side than the other, and to feel whether there is any obvious swelling or localised resistance to indicate the region or organ from which the inflammation started. The abdomen in peritonitis is often actually tender to the touch, and owing to the contraction of muscles is described as of a board-like hardness. This is in contradistinction to the appearance of the abdomen in intestinal obstruction, which likewise is distended but not rigid, unless peritonitis is superadded. If there is only localised tenderness the abdominal muscles may be felt to tighten under the hand, becoming, as it is termed, "on guard."

*Percussion.*—The abdomen should be percussed lightly all over in order to ascertain if there is any accumulation of fluid. The flanks are particularly to be noted, as it is there that fluid is liable to gravitate.

*Rectal examination.*—This should always be done with the idea of discovering if possible some source of infection, such as an inflamed appendix, ovary or Fallopian tube, or an accumulation of purulent fluid in Douglas's pouch.

*Examination of the blood.*—A pathological leucocytosis is found very

shortly after a perforation of any organ, and a knowledge of this fact may be an aid to diagnosis in a suspected case of peritonitis and to distinguish it from typhoid fever or colic; it may also be used as a means of ascertaining the progress of the disease. The presence of a leucocytosis, however, is not an infallible guide to peritonitis, because in the worst and most acute cases, when the reaction of the individual is low, the number of leucocytes is not raised and may even be diminished. A rapid pulse in conjunction with a falling temperature and a low leucocyte count are a bad sign.

**Pathological results of diffuse peritonitis.**—The fluid which is exuded is at first clear, but soon becomes turbid, and if examined under the microscope is seen to contain pus, red blood-cells and bacteria. Later, the fluid tends to assume the appearance of ordinary pus and fills the various pouches of the peritoneum, accumulating in largest quantities in the dependent portions, such as the pelvis and flanks. The surface of the intestines soon loses its bright polished appearance, the vessels on the surface becoming congested, and later small petechial hæmorrhages appear under the epithelium. Sticky lymph, which tends to glue coils of intestine together and helps to limit the disease, is also exuded. If death supervenes it is generally found that one or more types of organisms are present in the heart's blood, and death is due to a blood infection, as may be evident by the presence of numerous septic infarcts in such organs as the spleen, lungs, and kidneys. In cases that recover a steady general improvement takes place, shown by a slowing of the pulse, cessation of vomiting, and recovery of the function of the bowel, as indicated by the passage of flatus and fæces. The physical signs gradually disappear or become localised to the region of the onset of the trouble, where a circumscribed abscess may form. The adhesions arising during the inflammatory process may be absorbed, or may persist causing permanent adhesions and contractions which may in the future give rise to complications.

**Differential diagnosis** has to be made from colic, intestinal obstruction, ectopic gestation, and pulmonary complaints.

*From colic.*—Seen in the early stages it may be very hard to distinguish from colic, and for that reason it is advised not to give opium for the relief of pain until the diagnosis is made, owing to the masking of symptoms. Observation for a few hours will make the diagnosis clear, and, further, leucocytosis is not found in the case of colic.

*From intestinal obstruction.*—The persistent vomiting, pain, distension and constipation associated with an acute case of peritonitis often suggest intestinal obstruction. There are two main differences—in peritonitis the constipation is not absolute, as it is in obstruction, and in the latter case the abdomen, though distended, is not rigid.

*Ectopic gestation* is distinguished from peritonitis by the signs of internal hæmorrhage, a tarry vaginal discharge, and usually a history of amenorrhœa.

*From pulmonary complaints.*—In early pneumonia and pleurisy, especially when the thoracic side of the diaphragm is affected and before the advent of physical signs, the abdomen may be painful, tender and contracted, thus simulating very closely peritonitis. In many instances the abdomen has been opened under misapprehension, the diagnosis only being made later with development of physical signs; the increased rate of respiration, grunting expiration, and blue colouration of the lips should put the surgeon on his guard.

**Treatment of acute general peritonitis.**—An acute peritonitis requires drainage. Seeing, however, that the source of the inflammation is commonly some intra-abdominal lesion, the right course is to open the abdomen, remove

or suture the offending organ, such as a gangrenous appendix or perforated gastric ulcer, and then provide drainage for the pus. Necessarily the preliminary abdominal incision depends on the diagnosis of the original source of the trouble.

*Drainage of the peritoneal cavity.*—The peritoneum is not an easy cavity to drain, because there are so many pockets bounded by loops of intestine and because adhesions form so quickly between adjacent coils. Three main places where fluid tends to accumulate are the pelvis and the flanks. The pelvis may be drained by an incision in the middle line above the pubes, but a better way in the female is through an opening in the posterior fornix of the vagina: the flanks may be drained by an incision in either loin. The great omentum tends to shut off the upper from the lower part of the abdominal cavity, and if pus accumulates in the upper part the tube may be inserted through the middle line below the liver. Drainage is seldom efficient for long, because the tube becomes plugged either by a loop of intestine which covers the hole or by adhesions between adjacent coils of intestine. If there is much pus it is sponged out with dry swabs, but on no account should an attempt be made to pick off pieces of lymph.

*Bacteriological examination.*—Wherever possible a microscopical examination of the pus should be made at the time of the operation, a film stained and an immediate diagnosis of the infecting organism made. The appropriate serum may then be given without loss of time and cultures made for the preparation of vaccines.

*After-treatment.*—The patient should be put back to bed and well propped up with pillows, so that fluid may run by gravitation to the lower part of the peritoneal cavity, where absorption is not so rapid. The treatment then to be carried out may be directed on the following lines:—

1. Towards lessening shock and towards flushing out and preventing secretion by the injection of saline fluids either into the rectum, under the skin, or into a vein.
2. Promotion of the action of the bowel and prevention of distension by the use of the rectal tube, enemata, and purgatives, such as calomel in repeated small doses, or the use of drugs acting on the muscular part of the intestine, such as eserine sulphate and strychnine.
3. Maintenance of the strength by feeding with small quantities of fluids.
4. Use of vaccines and sera.

The hopeful signs are cessation of vomiting and a gradual fall in the pulse-rate and temperature.

## Special Forms of Acute General Peritonitis.

**Acute pneumococcal peritonitis** may be associated with a general infection of the pulmonary organs, or it may be a primary lesion, infection occurring through the blood-stream. Children are most commonly affected, but adults are not spared. It is considered that the infection is a little less virulent than a streptococcal one, but owing to the fact that the diagnosis is often not made till after some time has elapsed, there being no distinctive symptoms, the mortality is great. The diagnosis is made at first by exclusion, no cause, such as appendicitis, being found to account for the symptoms. Film preparations may show the pneumococci, but it is difficult often to make a diagnosis by a film preparation only, and the result of cultures must be awaited. The treatment consists in drainage of the peritoneum, and recourse may be also had to vaccines or sera.

**Gonococcal peritonitis** occurs as a sequel of gonorrhœa and is found chiefly in females, both adults and children, the organism gaining entrance to the peritoneum either through the ostium of the Fallopian tube or by rupture of a pyosalpinx. The infection, which is generally limited to the pelvis, causes much matting of the intestines in the lower part of the abdomen, and rarely spreads to the general cavity. In the male sex the disease is rare, infection, when it does occur, being believed to spread from the vesiculæ seminales. Diagnosis is made on a bacteriological examination, and it is aided by finding gonococci in the vaginal or urethral discharge. Recovery often takes place without operation, though incision and drainage of the pelvis or removal of a pyosalpinx may be necessary.

## Localised Infective Peritonitis.

One of the safeguards against a generalised peritonitis is the great power of the peritoneum to form adhesions and to shut off an inflamed area or suppurating focus from the general cavity. This is excellently well seen in connexion with inflammation of the appendix. Supposing this organ becomes inflamed, and organisms escape from its interior, a peritonitis around it very quickly results: in some instances, whether from the failure of resistance of the individual or virulence of the infection, the inflammation spreads, and a generalised peritonitis results as detailed above. Luckily, however, this is by no means the usual result; peritoneal adhesions, which form quickly, tend to stop the spread of infection and hem-in any pus that forms, so that a circumscribed abscess, the walls of which consist of loops of intestine gummed together by sticky lymph and later fastened by fibrous bands, results.

The subsequent changes are:—

1. The tissues gain the upper hand, the organisms are killed, the exudate absorbed, and a complete recovery ensured, the only sign of any strife remaining being a few peritoneal adhesions; or

2. The abscess, though remaining circumscribed, slowly increases in size, so that it points or bursts on to the surface of the abdomen or into the bowel; or

3. The abscess bursts into the peritoneal cavity, and sets up a general infective peritonitis.

The *treatment* of such a localised abscess is incision and drainage.

**Subphrenic abscess.**—Purulent fluid within the abdomen, if not rapidly fatal from general peritonitis, and if not well shut off, tends to collect in the upper part of the abdomen, being aided thereto, partly by the suction action of the respiratory movements, and partly by the course of the lymph flow. The term "subphrenic abscess" is given to any collection of pus under the diaphragm, though the origin of such suppuration may be due to a number of different causes, as follows:—

1. Those which arise in the neighbourhood of the diaphragm owing to leakage from, or perforation of, a gastric or duodenal ulcer, a leaking gall-bladder or pancreatic abscess, or some rarer cause, such as abscess of the liver or spleen, or a suppurating hydatid cyst.

2. Those which arise at a distance from the diaphragm. The most frequent cause is from a suppurating appendix or a leaking pyosalpinx, the pus tracking upwards behind the cæcum and ascending colon. Other causes are a perforated typhoid ulcer, perinephric abscess, or any other suppuration within the abdomen.

The space below the diaphragm is divided into two compartments, the right

and the left, by the falciform ligament, and is subdivided again into an anterior and posterior space by the coronary ligament; in any of these pus may accumulate, according to the region and course of the suppuration, though the abscess is generally situated on the same side of the body as the organ from which the original suppuration arose. The abscess may contain pus only or pus and gastric contents, or gas, arising either from the perforation of hollow viscera, or from the development of gases owing to the growth of such gas-producing organisms as the colon bacillus and anaerobic bacteria.

FIG. 367.—*a*, Subphronic abscess. Following perforation of a gastric ulcer. *b*, The perforation, marked by the insertion of a rod. (St. Bartholomew's Hospital Museum.)

*Course of abscess if left undrained.*—(*a*) The patient may die from septicæmia, the organisms having caused a general infection.

(*b*) The abscess may burst into the general peritoneal cavity and set up general peritonitis.

(*c*) It may burst into some part of the intestinal tract, such as the stomach or intestine, discharging itself and resulting in a spontaneous cure.

(*d*) Infection may spread through the diaphragm to the pleural cavity, giving rise to a septic pleurisy and empyema. In such a case following a perforated gastric ulcer, if the empyema is opened and drained, food taken by

the mouth may appear shortly afterwards through the opening in the chest, showing that there is a free communication through the diaphragm with the stomach.

*Diagnosis.*—The disease is usually insidious in its onset, and the diagnosis often extremely difficult owing to the depth of the abscess from the surface of the body. The prominent signs are—pain, vomiting, a sustained high temperature and high pulse-rate, associated with an increasing leucocytosis and progressive emaciation. If these signs are present after some such operation as for a perforated gastric ulcer or a suppurating appendix, when the symptoms, instead of clearing up, tend to get worse, the suspicions of the surgeon must be aroused to the possibility of an accumulation of pus below the diaphragm, and an attempt made to localise it. Physical signs are commonly few, though pain is generally ascribed to the region of the abscess, in which there may be some abnormal swelling or resistance and some dulness on percussion. This is, however, not an invariable sign, as such an abscess may, if it contains gas, be resonant on percussion.

An X-ray examination may reveal the abscess by the presence of a dark shadow, but more often it is only helpful in ascertaining if the level of the diaphragm is raised or if the movements of that muscle are interfered with.

*Treatment.*—The abscess should always be opened and drained if possible, but it is highly advisable that the presence and situation of the pus should be determined accurately before starting any operation, and to do this punctures should be made by means of an exploring needle. The needle should be of sufficiently large calibre to allow of the passage of thick pus, and should be at least 3 inches long and connected with a suction pump or aspirating bottle. A general anæsthetic having been given and all preparations made for the operation, the needle is passed into the suspected spot, though usually several punctures through several intercostal spaces have to be made before pus is reached. When pus is found the needle should be left in and an incision made down to it, the operation being planned to give the best access to the abscess and to allow of its free drainage afterwards. If the abscess points on the anterior abdominal wall it is best opened by an incision in front, but if on the posterior surface the transpleural route may have to be employed. In this case the diaphragm should be firmly stitched to the intercostal muscles so as to avoid infection of the pleural cavity, and it may be advisable to perform the operation in two stages. If the abscess has infected the pleural cavity and given rise to an empyema, then the right course is to resect a rib and drain the pleural cavity, with the expectation that the abscess will empty itself in this manner and heal. The mortality connected with this disease is high, due partly to want of recognition until it is too late to prevent a general blood infection, and partly to the fact that it is difficult to drain such an abscess efficiently because it is deep and often multilocular.

## Chronic Peritonitis.

By this term is meant infection by the organisms of tuberculosis, syphilis, and actinomycosis, and not the result of long-continued pyogenic infection with the thickening of the peritoneum which is an example of repair after injury.

**Tuberculous disease of the peritoneum.**—*The mode of entrance of the tubercle bacillus.*—The tubercle bacillus gains entry to the peritoneum in different ways. It may spread to it from an ulcer in the intestine, or from the breaking down of a mesenteric or retro-peritoneal gland; it may reach it

through the diaphragm from the pleura or through the blood-stream as a part of a generalised tuberculosis. The peritonitis may be apparently the only manifestation of tuberculosis, though in general it is secondary to a similar process elsewhere.

*Morbid anatomy.*—The peritoneum, which is inflamed and irritated, exudes a quantity of fluid, which in the early stages may be clear and yellow-coloured, but later sero-purulent and sometimes blood-stained. Tubercle bacilli are rarely demonstrable in the fluid, but it is infective if injected in guinea-pigs. The surface of the peritoneum is studded with large numbers of small miliary tubercles or thickened and opaque, as the outcome of the long-continued inflammation. Adhesions between loops of intestine and the abdominal wall are frequent, and in some instances the matting is extreme. The omentum becomes thickened and rolled up so as to give the abdomen a lumpy feel. The mesentery, too, is thickened and swollen, and its glands are commonly enlarged and often breaking down and caseous.

The clinical appearances vary so much under different conditions that for ease of description they may be grouped under three main headings, though intermediate types are common :—(1) The ascitic form ; (2) the fibrous form ; (3) the ulcerating form.

1. *The ascitic form.*—As the name implies, this variety is characterised chiefly by a large effusion of fluid, and the abdomen when opened does not reveal any large amount of matting of intestines, but a number of miliary tubercles scattered over the peritoneum. The fluid is usually clear and straw-coloured, rarely blood-stained. The clinical features in connexion with this form are chiefly malaise, fever, wasting, vomiting and constipation, accompanied by great enlargement of the abdomen and the presence of ascites.

2. *The fibrous form.*—Here the clinical aspect is not so serious as that mentioned above, and there is evidence of an attempt at repair and recovery. Ascites, if present, is always slight, and the fluid clear and rarely purulent. There is considerable matting of the intestines to one another and to the abdominal wall, much fibrosis accompanying the efforts at repair. In contradistinction to the ascitic form, this variety is often called a *dry* peritonitis.

3. *The ulcerating form.*—This is associated with ulceration and caseation together with the formation of localised abscesses, with or without secondary infection. If the abdomen is opened there is seen a confused medley of matted intestines, covered with grey granulations and small areas of caseation. If the adherent loops of intestine are separated, small loculi containing pus or caseous material are seen. It is likely that one of these cavities may become infected and an abscess form, usually in the neighbourhood of the umbilicus, and eventually it may reach the surface, burst, and leave an intractable form of fæcal fistula. The clinical aspect of such patients is miserable in the extreme. They have generally been ill for a long time, are extremely emaciated and feeble, have a high temperature, are subject to profuse sweating, and are afflicted with vomiting and diarrhœa. The abdomen is distended, and there are areas of dulness and resonance, with hard masses in some parts and fluctuation in others.

*The operative treatment* is not attended by great success. The best results have followed in the chronic cases, and especially in those in which the peritonitis was encysted. When there is general ascites and no evidence of generalised tuberculosis, the abdomen may be opened and the fluid let out. The abdominal cavity should not be drained, however, for fear of a fæcal fistula forming. In the dry or adhesive variety no good can come of operation. The one instance in which it may be said that operative

interference is clearly indicated is when an abscess forms and appears likely to burst. In such a case the abscess should be incised and drained with a view to the prevention of a distressing fæcal fistula.

**Localised tuberculous peritonitis.**—In the case of peritonitis following the breaking down of a retro-peritoneal or mesenteric lymphatic gland there may result a localised area of inflammation which causes adhesions to surrounding loops of intestine. It is common to find such a condition in the

FIG. 368.—Serous cysts of the mesentery—pedunculated thin-walled vesicles. (St. Bartholomew's Hospital Museum.)

neighbourhood of the cæcum, and it is not at all unusual for it to simulate a chronic appendicitis, for a lump will be formed in the right iliac fossa, which gives rise to pain and tenderness and some rise of temperature. If the process is a little more extensive a large hard mass may be found involving the whole of the cæcum and causing adhesions to neighbouring viscera. The swelling may be so great as to give rise to symptoms of intestinal obstruction, and the naked-eye appearances resemble, and are sometimes difficult to distinguish from, carcinoma of the cæcum.

**Syphilitic peritonitis.**—This is most often seen in connexion with a gum-

matous infiltration of the liver and spleen, in which the peritoneal covering participates in the disease, becoming thickened, tough and opaque, and in some instances almost as hard as gristle.

**Actinomycosis of the peritoneum.**—Intestinal actinomycosis starts most frequently in or about the appendix and cæcum, and infection of the peritonsum is due to a spread from these organs. The disease commonly results in the formation of a very chronic abscess.

## Tumours of the Peritoneum, Omentum and Mesentery.

Primary growths of these structures are not often met with, and when discovered it is generally by accident, in the course of an operation or at a post-mortem examination. They may be endotheliomata, fibromata, myxomata, lymphangiomata, or lipomata. The last named arise most frequently as tumour-like enlargements of the appendices epiploicæ of the colon. They may become separated from their attachment to the colon and then form free peritoneal bodies, which may undergo calcification. Secondary growths, usually carcinomatous in origin, are frequent. They generally originate in an abdominal viscus, such as the rectum, colon, or uterus, and take the form of isolated nodules, which in the later stages coalesce and cause matting of the intestines and an exudation of ascitic fluid. In some instances the peritoneum becomes entirely beset with small miliary growths resembling tubercle.

Peritoneal dermoids and complex teratomata, due to fœtal inclusions, may develop in women about the neighbourhood of the ovary.

Of the animal parasites affecting the peritoneum must be mentioned the echinococcus and the cysticercus, both of which are rare in Great Britain.

Serous cysts may develop in any part of the peritoneum and mesentery, and cases are recorded in which the abdominal cavity was more or less filled by pedunculated thin-walled vesicles. The origin of some of these cysts is probably dilatation of the lymphatic vessels, and others are of the nature of cavernous lymphangiomata. A spurious cyst may also be formed between adherent loops of intestine, a small portion of the peritoneal cavity becoming completely isolated.

## Section XXI.

### HERNIA.

**Definition.**—A hernia (Greek *hernos*, a sprout or bud) is the protrusion of any viscus from its containing cavity. Thus one talks of a hernia cerebri, hernia testis, or of a hernial protrusion of the lung. Speaking generally, the term implies a saccular protrusion of peritoneum through the abdominal wall, the sac containing a portion of the bowel, omentum or more rarely some other abdominal viscus.

The popular cognomen "rupture" so commonly used is a misnomer, as it implies the actual tearing of some portion of the abdominal wall by violence, which is not the fact, and the misunderstanding leads to much litigation.

**Causation of a hernia.**—Much has been said about the actual cause of the commencement of a hernia, and it is still impossible to make a comprehensive statement on the subject. It is quite clear that often, and it may be always, there is a congenital sac into which a small portion of the bowel or other abdominal viscus protrudes, which if conditions are favourable tends to become larger and larger, and if left may be the cause of great inconvenience and even a source of danger to life. The congenital origin is established in almost all forms of inguinal and in many of the umbilical herniæ, and it seems likely that this is the case as well in the femoral, obturator, and lumbar forms.

**Contributory factors.**—These are many, and may be divided into :—

1. A weak and slack condition of the abdominal walls, such as is produced in pregnancy and by rapid emaciation of previously stout people, or in persons weakened by disease.

2. Gastro-enteritis, causing distension of the intestines and increased intra-abdominal pressure—this is particularly the case with infants and young children.

3. The excessive formation of fat in the omentum and mesentery, causing increased intra-abdominal pressure.

4. Occupations involving severe muscular strain.

5. Any disease involving continued straining and in which increased abdominal pressure is induced, such as straining in micturition consequent on a stricture of the urethra or an enlarged prostate, or constant coughing, as in bronchitis and emphysema.

6. Excessive length or prolapse of the mesentery, favouring the descent of the bowel into a preformed sac.

**Constituent parts of a hernia.**—A hernia consists of two portions—the sac and its contents.

*The sac.*—The sac may be present, and often is, without any protrusion into it, and as such is not a true but only a potential hernia into which a piece of bowel or omentum may be protruded at any moment owing to the action of one or several of the above-mentioned causes.

The sac is a pouch of peritoneum which communicates by means of a neck or mouth with the general peritoneal cavity. The neck of the sac is broad or narrow according to the amount of stretching which it has undergone. The sac is permanent; it does not become reduced into the abdominal cavity

because it is adherent to the surrounding tissues. If it remains undisturbed for long periods, it shrinks and in young subjects may shrivel, so that it becomes only recognisable as a strand of fibrous tissue.

In the early stage it is as thin as tissue-paper and transparent, but becomes hypertrophied in old-standing herniæ, developing into a thick, tough membrane with a cross-section measuring perhaps one-sixteenth of an inch.

The sac is liable, as all other structures are, to inflammation and disease —it becomes inflamed as the result of injury and infection. It becomes thickened and roughened; adhesions form between it and its contents; it shares in a general infection of the peritoneal cavity or becomes tuberculous; calcareous plates form in it. In other words, it is affected in the same way as the rest of the peritoneal surface of the abdominal cavity.

It is clearly to be understood that the size of the sac depends on distension by its contents, and that a large hernia does not develop in a moment as the result of some muscular exertion. It is true that in the presence of a congenital sac a patient who previously has never noticed any swelling may, as the result of some exertion or even coughing or sneezing, have a piece of bowel descend into the sac, which may, if the sac permits, reach even to the bottom of the scrotum. Such instances are a fertile source of litigation under the Workmen's Compensation Act, and the medical witness is constantly asked whether a hernia can be the outcome of an injury or sudden muscular exertion. The true answer seems to be that the sac cannot be produced by any such injury, but that, granting the presence of a preformed or congenital sac, any sudden strain may determine the descent into the sac of an abdominal viscus, and this may be the first indication to the patient of any existing abnormality and is attributed in all good faith to the supposed injury.

*Contents of the sac.*—All the various abdominal viscera have been found at different times in hernial sacs with the exception of the liver and pancreas. It is natural that those organs with the freest range of movement, namely the intestine, large and small, and the omentum are the most frequently met with. In infancy, descent of the omentum is rare on account of its small development, but common in adult life.

The cæcum and appendix are not uncommonly present.

A hernia of large dimensions may contain many organs, so that colon, jejunum, omentum, and part of the stomach may be found together. As a result of repeated small injuries the peritoneum covering the contained viscera becomes inflamed and subsequently thickened and rough. Hence adhesions form, binding loops of intestine to one another or to the wall of the sac and so preventing reduction into the abdomen. In the case of such chronic peritonitis there may be some serous fluid secreted by the peritoneum, which increases the size of the swelling and renders treatment very difficult. Suppuration within the sac rarely occurs.

**Common sites of hernia.**—Hernia through the inguinal canal is by far the commonest variety. Next in order of frequency is femoral hernia, passing through the femoral canal, and then the umbilical form. Ventral hernia other than the umbilical is rare except as the result of injury and abdominal operations.

*Other sites of hernia.*—These are—obturator, lumbar, perineal, gluteal, ischio-rectal, and vaginal. They will be alluded to briefly later on.

**Diagnosis of a hernia.**—A hernia forms a swelling in the neighbourhood of a known hernial site. Its most remarkable feature is an impulse on coughing —that is to say, with raised intra-abdominal pressure the hernia increases in size and tenseness.

**Method of examination.**—The patient should be placed in the erect position in a good light and a careful observation made to see if on coughing there is a visible impulse. The reason for advising the erect position is that the hernia may become reduced on lying down, and so may not be detected. If nothing is seen it is advisable to make the patient walk about or bend down and strain in order to see if anything comes down. In the event of a reducible hernia which only appears now and then it is hard to come to any conclusion, and a diagnosis should never be made unless a swelling is seen or there is reliable information that a descent does take place.

If a swelling is present the next thing to ascertain is whether it does or does not communicate with the abdomen. For this purpose the patient should be in the recumbent position, and an attempt made to see if the fingers will meet between the swelling and the abdominal parietes. In this way a hernia is distinguished with ease from a hydrocele or tumour of the testis.

An attempt is then made to reduce the swelling, reducibility being an additional evidence of a hernia. It is not an infallible sign, for a hernia may have become irreducible from adhesions or other cause. The majority, however, are reducible, and if bowel is present reduction is accompanied by a characteristic gurgle.

Invagination of the scrotum and insertion of the finger into the external ring is of little assistance—all it tells is the size of the external ring, and the descent of a hernia in no way depends on this.

By means of percussion a surgeon may discover whether a hernia contains bowel or omentum.

**Clinical states of a hernia.**—A hernia may be reducible, irreducible, obstructed or strangulated.

**A reducible hernia** is one in which the contents of the sac can be reduced into the abdominal cavity. As has been stated before, the sac is permanently fixed to the surrounding tissues and cannot be reduced. In many cases the contents of the sac are reduced on lying down or by very slight pressure. In others, manipulation known as taxis has to be employed. To effect this the patient should be lying down ; the neck of the sac is grasped with the fingers of the left hand so as to make a sort of funnel, and the right hand is made to envelop the fundus of the hernia, when by a squeezing movement the contents are made to slide through the neck into the abdomen. A knowledge of the exact amount of pressure that may be exerted with safety can only be gained by experience.

*Symptoms of a reducible hernia.*—The symptoms complained of by patients vary extraordinarily : there may be none, and some people refrain from seeking advice until a hernia becomes of unmanageable proportions. Usually there is a certain amount of dragging pain and colicky sensation in the abdomen, especially on lifting weights and violent exertion.

*Prognosis.*—If untreated, a hernia is a risk to life from strangulation. If efficiently controlled by a truss, an otherwise healthy person is accepted by an insurance office as a first-class life.

*Treatment.*—The best treatment is to have the hernia cured by operation, otherwise to have it controlled by a truss.

**An irreducible hernia** is one in which the contents of the sac cannot be returned into the abdomen.

The following are the common causes of irreducibility :—

1. Adhesions between the contents of the hernia and the wall of the sac.
2. Increase in the size of the omentum from deposition of fat, so that it is no longer capable of passing through the narrow neck of the sac.

3. Such increase in size of the contents of the hernia that there is no longer accommodation for them within the abdomen.

*Symptoms of an irreducible hernia.*—These are similar to those of the reducible form, except that the hernia cannot be returned into the abdomen. Frequently the two forms may coexist, part of the contents being reducible and part irreducible. Painful sensations may be more prominent and disability, from the point of view of gaining a livelihood, greater.

The *treatment* is either palliative by means of a truss or radical by operation. Unless there are clear indications militating against any operative procedure it is better to advise the radical operation, for the reason that an irreducible hernia is more dangerous to life and because of the difficulty of supporting it

FIG. 369.—Strangulated femoral hernia. A partial enterocele, or Richter's hernia, with ulceration and peritonitis. *a*, Femoral artery. *v*, Femoral vein. (St. Bartholomew's Hospital Museum.)

with a truss. Trusses can be made to retain an irreducible hernia, but they are irksome and often inefficient.

**Incarcerated or obstructed hernia.**—These terms are generally applied synonymously to an irreducible hernia in which the lumen of the protruded intestine has become obstructed by a collection of fæces or undigested food, but in which the vascular supply of the bowel is not impaired. This condition is most frequently met with in old people, women with umbilical herniæ, and men with large scrotal herniæ, and if neglected strangulation is liable to supervene.

*Symptoms.*—As in strangulation, there may be constipation, colicky pains, nausea and perhaps vomiting; but the local signs of strangulation are less marked. Thus there may be little or no local pain and no tension in the sac,

though at times it may become larger than before the incarceration occurred. The impulse on coughing may still be present, and hard or putty-like fæcal masses may, perhaps, be felt. The symptoms, however, gradually merge into those of strangulation, and it is often difficult to distinguish mere obstruction from strangulation, especially when the former is associated with some inflammation of the sac.

*Treatment* consists in purgative enemata, rest in the recumbent position, restriction of diet, and a radical cure by operation, or the application of a suitable truss when the obstruction is relieved.

**Strangulated hernia.**—This term implies that the hernial protrusion has been nipped so tightly that, in addition to being irreducible, the arterial supply is impeded and the lumen of the bowel occluded so that no fæcal contents are able to pass ; if the condition is not relieved intestinal obstruction supervenes, the constricted bowel or omentum becomes gangrenous, and the patient dies.

*Causes of strangulation.*—1. The usual cause is the sudden forcing of a piece of bowel or omentum through an aperture that is so small that it is at once tightly gripped. This may occur the first time that a hernia makes its appearance.

2. In the case of an old hernia or in one already irreducible the exciting cause may be the sudden protrusion into the sac of a piece of bowel in addition to that already present and for which there is no room.

3. Swelling of the intestine from inflammation or from becoming obstructed by accumulation of wind or fæces.

*Seat of constriction.*—There is no law that determines exactly the seat of constriction in all herniæ. It may be in the neck of the sac or at one of the tendinous apertures through which the hernia protrudes. Thus in the case of inguinal hernia the constriction may be at the neck of the sac or, as is more common, at the external ring. In femoral hernia the constriction is almost always caused by pressure of Gimbernat's ligament.

The exact nature and situation of the constriction is one rather of academic interest, because the surgeon has to divide whatever is causing the strangulation, and it is very often difficult or impossible to say with any exactitude what it is, for the parts become so stretched as to be unrecognisable.

*Clinical symptoms of strangulated hernia containing bowel.—Local signs.*—The hernia is irreducible, it is tense and tender, and there is no impulse on coughing.

*General signs.*—By far the most important symptoms are those caused by the mechanical obstruction to the lumen of the bowel. The patient has the signs of intestinal obstruction—that is to say, there is complete stoppage of the passage of wind and fæces, a condition which, if long maintained, is incompatible with life. As a result, too, of the mechanical obstruction and the continuance of peristalsis, vomiting occurs, continues, and becomes a prominent sign.

The vomit, which at first consists of the contents of the stomach, becomes mixed with bile, then becomes brown in colour and begins to look and smell like fæces, and is termed feculent.

It is to be insisted on that a patient who is suffering from complete constipation and vomiting has the signs of intestinal obstruction, is in a critical state, and must be relieved at the earliest possible moment. It is to be remembered that such a patient with a strangulated hernia sometimes has an action of the bowels after the strangulation has occurred owing to the portion of the bowel below the strangulation becoming emptied. If there is any

doubt as to the obstruction it is as well to administer an enema, if necessary more than one, and to see whether after the first washing any flatus or fæcal contents are passed. The acuteness of the attack varies, and the higher up in the bowel the obstruction, the more urgent and acute are the symptoms. As the result of the inability to pass wind and fæces the abdomen becomes distended, and in the later stages tympanitic and painful. It is not rigid as in peritonitis. If it is watched for a few moments coils of intestine are seen in a spasm of peristalsis trying to overcome the obstruction, and it is noted that the peristaltic wave is coincident with a spasm of pain.

In the later stages the face becomes pale and anxious, the pulse small and wiry, the tongue brown and furred, and if the strangulation is not relieved the patient dies of collapse, peritonitis following gangrene of the bowel or exhaustion from constant vomiting.

*The diagnosis of strangulated hernia.*—The symptoms of strangulation are generally so obvious that the diagnosis is easy. It rests mainly on the fact that vomiting occurs after a hernia previously reducible becomes irreducible. As this cannot always be ascertained without some doubt, a rule has been laid down and carried out for some years that a swelling at one of the hernial apertures whose nature cannot be determined must be explored if there are signs present pointing to intestinal obstruction; the incision, even if made on a mistaken diagnosis, does no harm, and if it is not made and an obstruction exists the patient may lose his life.

The rupture has existed usually for some years before it becomes strangulated, but occasionally it is protruded and strangulated at the same instant (see also section on *Intestinal Obstruction*).

*Strangulation of omentum.*—When omentum only and no bowel is nipped the symptoms are similar to those above mentioned, only they are not so severe and the signs of intestinal obstruction are not complete.

**Other conditions simulating strangulated hernia.**—1. Torsion of a partially descended testis gives rise to signs and symptoms very similar and sometimes indistinguishable. In such cases it will be noted that the corresponding side of the scrotum is empty.

2. Intestinal obstruction from some other cause, such as a carcinoma of the bowel in the presence of a pre-existing hernia.

3. General peritonitis due to some other cause, such as appendicitis in the presence of a pre-existing hernia.

4. Torsion of omentum: this is a rare condition, usually associated with the presence of an inguinal hernia. The symptoms simulate closely those of strangulation, and it is commonly only after the abdomen has been opened that the diagnosis is made. The treatment consists in ligature and removal of the twisted omentum.

**The pathological effects of strangulation.**—In addition to the stoppage which is brought about by the mechanical occlusion of the bowel, very serious changes occur in the hernia itself affecting the contents of the sac, the sac itself, its coverings and the adjacent peritoneum.

Following the nipping of the intestine and constriction of the vessels there is interference with the return of venous blood, and, in consequence, rapid congestion of the part with much swelling and œdema. This leads to exudation of fluid both into the lumen of the bowel and into the sac itself. This fluid, at first serous, soon becomes blood-stained, owing to migration of red blood corpuscles; and later, owing to damage to the wall of the intestine, even without visible lesion, bacteria pass from its interior into the fluid in the sac, and may be the cause of septic peritonitis. The colour of the bowel, at

first blue, deepens until it becomes almost black, and if the condition is unrelieved inflammation sets in, then ulceration, and eventually the whole part becomes gangrenous. The bowel then collapses, the lumen is opened, and in the great majority of cases septic peritonitis results. This is the termination of most unrelieved cases of strangulation, though very occasionally a fæcal fistula may form and a spontaneous cure result.

The changes in the sac wall and in the tissues covering the sac are not so marked, but they share in the general inflammation. The skin over the swelling becomes red and œdematous and the whole part swollen. Instances have been known in which an inflamed and strangulated hernia has been mistaken for an inguinal bubo and opened as such.

In the later stages the peristalsis of the intestines ceases, the abdomen becomes distended and tympanitic, and with the onset of peritonitis these symptoms are more marked. If the intestines are examined after death from strangulation it will be found that the proximal end of the gut is much distended and the distal portion collapsed.

Local peritonitis about the neck of the sac may act in a beneficial manner, gluing the portions of the intestine together, and tending to prevent extravasation into the abdominal cavity.

*The treatment of strangulated hernia.*—The strangulation must be relieved and the contents of the sac returned into the abdomen with as little delay as possible : every hour adds to the danger (gangrene may occur within twenty-four hours). The result will depend to a great extent upon the length of time the strangulation has existed : purgatives for overcoming the obstruction are not only useless, but absolutely injurious ; prolonged and forcible attempts to return the bowel by taxis are unjustifiable and wholly to be condemned ; opium and morphia, by masking the symptoms, obscure the imminence of the danger. The patient should be placed under an anæsthetic, and, should the bowel not then slip back readily on again gently trying taxis, the operation for dividing the stricture should at once be proceeded with.

*The dangers of taxis are :—*

1. Bruising or laceration of an already damaged intestine.
2. Return of septic fluid or gangrenous bowel into the abdomen.
3. Reduction *en masse*. By this is meant laceration of the parts and the reduction of the hernia still strangulated into the abdominal cavity. It is rare now because of the increasing number of operations.

*The advantages of operation are numerous :—*

1. The obviation of bruising and laceration of the bowel.
2. An accurate examination of the contents of the sac can be made, and the risk of returning a piece of gangrenous bowel into the abdomen is obviated.
3. The operation for the reduction of the strangulation can be followed by the radical cure of the hernia.

**Treatment of strangulated hernia by open operation.—Herniotomy.**—This is by far the best treatment, and to be advised in all cases unless there is some grave contra-indication.

*Choice of anæsthetic.*—Although the operation can be done under a local anæsthetic, a general one is preferred on account of the freer exposure that can be made.

*Preparation of the patient.*—The affected parts should be shaved and the skin prepared with acetone and iodine.

If the strangulation is of long duration and vomiting is incessant, it is advisable to wash out the stomach before commencing the anæsthetic, so as

to avoid the inhalation of stomach contents into the air passages during the anæsthesia, an accident which is liable to cause bronchitis or pneumonia.

A free incision is made over the hernial swelling, the exact line of which varies according to the variety of hernia being dealt with. (The line of the incision will be dealt with subsequently.)

The incision is deepened through the tissues until the sac is reached. It is important that this should be recognised, because the wall may be very thin and the bowel pressed so close against it that it is liable to be injured on opening it. The sac is recognised by the fact that it is not shiny on the outer side, and the arrangement of the vessels is not transverse, as is the case with the bowel. If there is any doubt, a small piece is picked up with the forceps and very carefully incised with the scalpel held on the flat.

On opening the sac a small amount of fluid will escape as a rule. This fluid may be blood-stained and also infected with bacteria, and it is advisable that it should be sponged up and not allowed to escape. The sac having been opened, the contents should be explored and the exact condition ascertained.

The next step in the operation is the division of the constricting band. Great care is taken in this manipulation to avoid injury to the distended and strangulated bowel. The division of the band can be made from the inside or the outside. Without doubt it is safer to do it from the outside, by cutting down, with all the structures in full view, until the right layer is reached. If it is decided to divide the stricture from within, a director is passed within the sac until it comes to lie under the constricting band, and then a blunt-pointed bistoury is cautiously slipped along the groove until it is opposite the stricture, when with a gentle sawing movement the resisting structure is divided. The dangers to be avoided in this division from within are injury to the bowel, which, owing to distension, may insinuate itself into the groove of the director and be cut by the bistoury, or injury to a vessel which may be lying close to the stricture.

*Examination of the bowel.*—The stricture having been divided, the next step is to examine the bowel and ascertain with certainty whether or not it is viable. It must never be returned into the abdomen until a good loop has been pulled out so that a clear view is obtained of the part immediately pressed on by the constricting band, because it is there, if anywhere, that ulceration will be found.

*Course to be adopted when the bowel is viable.*—In a large majority of cases there is no doubt that the bowel, although perhaps congested, is not so injured as to be incapable of recovery. In this event the bowel is returned into the abdominal cavity. It is useful to remember that the loop that came down last is the first to go back, and that it is generally lying posteriorly. Any omentum that is in the sac is ligatured, cut off, and the stump returned into the abdomen. Next the sac is removed and the radical operation performed.

*Course to be adopted when the viability of the bowel is doubtful.*—If uncertainty exists in the surgeon's mind as to the viability of the intestine the following points should be observed :—

1. The surface of the bowel should not have lost its polish.

2. After the constricting band has been divided and the loop pulled out the bowel should begin to regain its normal colour in a very few minutes ; if it does not do so, the chance of recovery is slight.

3. If the surface of the bowel is pricked gently with a needle it will bleed, unless thrombosis of the veins has occurred.

If the surgeon is still in doubt it is better to treat the bowel as if it were gangrenous. If, however, there is only a small patch which is under suspicion,

as in a partially strangulated enterocele (Richter's hernia), it may be tucked in and a healthy piece drawn over it, by Lembert's sutures, without unduly narrowing the lumen.

*Course to be adopted when the bowel is gangrenous.*—There are three courses open to the surgeon, who must be guided in his choice by the condition of the patient :—

1. The ideal course is to pull down a loop of bowel, excise the gangrenous portion and do an immediate anastomosis, return the bowel into the abdomen, and finish with the radical operation.

2. If the patient's condition will not stand such a prolonged operation, a loop of bowel is drawn down, the gangrenous portion cut away and the two cut ends fixed in the wound, making an artificial anus. At a later stage, if the patient recovers, a second operation is done to close the opening.

3. If the patient is desperately ill and almost moribund, it is wise to do nothing more than to incise freely into the hernial protrusion without dividing the stricture, trusting to the adhesions at the neck of the sac shutting off the abdominal cavity.

This last method has the merit of rapidity, but of nothing else.

*After-treatment.*—This, as a rule, does not require to be very vigorous. If the stricture has been relieved, the vomiting, which previously was the distressing symptom, soon passes off, and the bowels will empty themselves without help. If there is a great deal of shock, hot bottles are applied and a saline infusion administered by the rectum. Strychnine is given hypodermically, both as a cardiac stimulant and also as an aid to peristalsis.

**Persistence of symptoms after division of the stricture.**—If the strangulation has been recognised and treated reasonably early, such an undesirable state of things rarely occurs. Should, however, the vomiting persist and the bowels remain unrelieved, the following possibilities have to be taken into consideration.

1. Peritonitis as the result of infection from the sac or from giving way of a portion of injured bowel within the abdomen. The signs of peritonitis then become evident (see p. 884), and the only chance of saving the patient is to open the abdomen and see and deal with what is amiss.

2. As the result of over-distension of the bowel from long occlusion and from the absorption of toxins, a condition of intestinal stasis supervenes although the stricture is relieved. If this is suspected at the time of operation, it is advisable to open a coil of intestine, allow the contents to flow off, and then to sew it up again. Drugs to aid peristalsis, such as strychnine and eserine sulphate, are of value here.

3. In rare instances two herniæ may be present, and the surgeon may have operated on, say, an inguinal hernia when the cause of the strangulation was really an obturator or femoral hernia which had been overlooked.

4. The symptoms are relieved and then recur after a few days' interval as the result of intestinal obstruction supervening from matting together of loops of bowel which were injured from the long nipping, but which were returned as viable into the abdomen.

## Special Forms of Hernia.

### Inguinal Hernia (Oblique or Indirect).

**General description.**—Of all forms of hernia this is by far the most common, and includes all varieties which pass through the inguinal canal.

The hernia, following the line of the spermatic cord in the male and the

round ligament in the female, leaves the abdomen by the deep or internal abdominal ring, traverses the whole length of the inguinal canal, appears at the external abdominal ring, and descends finally into the scrotum or labium, when it is termed *scrotal* or *labial*. If the hernia merely protrudes from the external ring it is called an *incomplete hernia* or *bubonocele*.

FIG. 370.—Right inguino-scrotal hernia. (From Eccles's "Hernia.")

**Surgical anatomy.**—In the adult the inguinal canal is about $1\frac{1}{4}$ inch long and runs parallel with Poupart's ligament, with an inclination downwards, forwards, and inwards. It extends from the internal abdominal ring, which is marked by a point $\frac{1}{2}$ inch above the middle of Poupart's ligament, to the external ring, situated immediately above and external to the crest of the os pubis. The canal is described as having an anterior and posterior wall, a floor and a roof. The anterior wall is formed by the aponeurosis of the external

oblique muscle, and in the outer third are found also some of those fibres of the internal oblique muscle which take origin from Poupart's ligament. The posterior wall is formed by the conjoined tendon of the internal oblique and transversalis muscles in the inner third and by the transversalis fascia throughout the whole length of the canal. Behind the transversalis fascia are the subperitoneal tissue and the peritoneum. The deep epigastric artery, a branch of the external iliac, is placed immediately internal to the internal abdominal ring. The roof of the canal is formed by the arching fibres of the internal oblique and transversalis muscles and the floor by the transversalis fascia, which passes downwards to be attached to Poupart's ligament.

A direct inguinal hernia does not pass through the inguinal canal, but lies altogether above and internal to it and to the inside of the deep epigastric artery. Clinically it may be difficult to distinguish from the oblique form, but it really has nothing to do with it and will be alluded to under *Hernia through the linea semilunaris* (see p. 920).

During its passage through the canal the hernial sac is bound up with the constituents of the cord, and enclosed in the cremasteric fascia in the male. The hernia lies in front of the vas, and when it descends into the scrotum is in front of or above the testis.

**Comparative anatomy of oblique inguinal hernia and its congenital origin.**—The formation of oblique inguinal hernia is closely related to the descent of the testis from the abdomen into the scrotum, and an understanding of the different varieties of inguinal hernia and the arguments as to their congenital origin necessitates a brief review of the embryology and comparative anatomy.

In the lower animals, as in the human embryo, the testes are located within the abdomen. In ascending the scale of the animal kingdom it is found that on reaching the family of Rodents the testes are situated at the external abdominal ring surrounded by an open pouch of peritoneum, and the testes can be drawn up and down into the abdominal cavity. In the higher animals, such as the monkeys, the testes descend to the bottom of the scrotum and remain there, but the surrounding pouch of peritoneum, now termed the processus vaginalis, persists throughout life with an opening into the abdomen. This is exactly the condition that is found in the human embryo just before birth; but in man development goes a stage further, and the pouch of peritoneum which envelops the testis is entirely obliterated, except that portion which immediately invests the testis and forms the tunica vaginalis. The various forms of inguinal hernia described below are the result of imperfect or partial closure of this processus vaginalis.

In the female there is a similar pouch of peritoneum formed in the inguinal canal: this is called the canal of Nuck, and a hernia may develop similarly in it. Further, in a way analogous to the male, this may become entirely obliterated, or if only partially so, may leave a small hydrocele—a cyst of the canal of Nuck.

## Varieties of Oblique Inguinal Hernia depending on Imperfect Closure of the Processus Vaginalis.

In the past it has been customary to denote these by such names as "congenital hernia," "infantile hernia," and the like. These terms are apt to be misleading, and hence the variety will be denoted by the anatomical condition.

**Hernia into the unclosed processus vaginalis.**—In the extreme case the processus vaginalis remains open without any attempt at closure or formation

of a tunica vaginalis, and a hernia may descend into the bottom of the scrotum at its first appearance.

**Hernia into the unclosed funicular process.**— In this instance development has proceeded a little further, the lower portion being closed off, forming the tunica vaginalis, but leaving an upper funnel-shaped process of peritoneum,

Fig. 371.—Left scrotal hernia. (From Eccles's "Hernia.")

known as the funicular process, communicating with the interior of the abdomen. Very often the obliterated portion of the processus vaginalis may be seen as a fibrous cord attached to the upper pole of the tunica vaginalis, and is known as the fibrous filament of Cloquet.

**Partial closure of the sac forming an encysted hydrocele of the cord.**— Partial obliteration of the processus vaginalis may take place simultaneously at the upper and lower ends, leaving a small sac in the middle, which becomes

distended with fluid, and is called an encysted hydrocele of the cord. This results in the formation of a tense swelling situated in the upper part of the scrotum or in the inguinal canal and may be mistaken for the testis.

**Hernia into the upper unobliterated portion of the processus vaginalis.**—This is the usual form of hernia and consists of a small sac; the latter may be only an inch long and marks the remains of the processus vaginalis, all the rest having been obliterated. Such a sac may be present for years without any descent of bowel or omentum into it; it is often found by dissection in young children, and undoubtedly in many of them it may disappear spontaneously, there being no reason that development should not go on after birth as well as *in utero*.

FIG. 372.—Hernia into patent processus vaginalis. (St. Bartholomew's Hospital Museum.)

*Relation to age.*—Oblique inguinal hernia is found at all ages, but it is much the most common in young infants. Another common period is between the ages of twenty and thirty, when strenuous occupations favour its appearance.

*Relation to sex.*—It is nearly twice as common in the male as it is in the female, and it is much more common to find it on the right than on the left side. This supports the congenital theory, because it is a known fact that the left testis descends from the abdomen before the right, and the closure of the processus vaginalis is completed at an earlier period on this side.

**Differential diagnosis of oblique inguinal hernia.**—Oblique inguinal hernia has first to be distinguished from other forms of hernia, especially the femoral variety; a mistake, however, should not be made if it is remembered that an inguinal hernia presents itself above Poupart's ligament and then descends into the scrotum, passing to the inner side of the spine of the os pubis, whereas a femoral hernia makes its appearance below Poupart's ligament and is external to the spine of the os pubis, the inguinal canal remaining empty.

Other swellings simulating inguinal hernia and having an impulse on coughing are:—

*Varicocele.*—In this the swelling is irregular and lobulated, and the individual veins are felt as collapsible cords. It is dull on percussion, and it is not reducible in the ordinary sense of the word, but always

disappears on lying down and reappears on standing up. The impulse on coughing is not definite, as in an inguinal hernia, but is more like a fluid thrill.

*Congenital hydrocele*, in which there remains a patent processus vaginalis containing fluid communicating commonly through a very narrow orifice with the abdominal cavity. The swelling is usually pyriform in shape, translucent, dull on percussion, and can usually be reduced slowly into the abdomen without the characteristic gurgle of a hernia, and will reappear slowly after reduction has been effected.

FIG. 373.—Right inguino-scrotal hernia in an infant.

*Psoas abscess.*—In the early stages this may present itself as a fluid swelling above Poupart's ligament and give an impulse on coughing, and so be mistaken for an inguinal hernia. Usually, however, there will be signs of deformity or rigidity of the back, which will clear up the diagnosis.

Solid and irreducible swellings simulating inguinal hernia are :—

*Enlarged and inflamed lymphatic glands.*—This is a fertile source of error, but a mistake is less likely to occur if it is remembered that it is very unusual for one gland only to be involved in an inflammatory process ; in the case of matting of the glands together the skin will usually be red and the other signs of inflammation present.

*Fluid swellings* (*e.g.*, hydrocele of the tunica vaginalis, encysted hydrocele of the cord, spermatocele and hæmatocele).—A little care will enable these

swellings to be distinguished from a hernia, because they are limited entirely to the scrotum and do not extend up to the abdomen.

In the female, also, a diagnosis has to be made from a cyst of the canal of Nuck, which is situated in the inguinal canal.

FIG. 374.—A single ordinary inguinal truss adjusted. (From Eccles's "Hernia.")

*All forms of enlargement of the testis.*—The same remarks apply to this as to the preceding class.

*A partially descended testis.*—The fact that the testis is missing from its normal position in the scrotum serves at once to distinguish this condition. It is to be remembered that a partially descended testis is very often associated with a hernia.

*Connective tissue tumours, such as fibromata, lipomata, and sarcomata.*—These

develop as isolated tumours in the connective tissues of the cord. There is, of course, no expansile impulse on coughing, though a heaving movement may be communicated to them through the abdominal wall.

**Treatment of oblique inguinal hernia.**—It should be a rule that every hernia occurring, at whatever age, should be treated and not left to itself with the idea of a spontaneous cure. There is an idea still prevalent among nurses that a child cannot be treated until the age of three or four years: this is quite erroneous, and is detrimental to the child. There is no doubt that in some instances infants do undergo a spontaneous cure, but it is impossible to foretell in which cases this will take place.

There are only two forms of treatment—namely, palliative, by means of a truss, and radical, by operation. In the choice between these two methods, it is to be remembered that the former is only palliative, and in the adult certainly does not effect a cure, and only occasionally in children. As regards operation, the mortality is so low as to be negligible, and with the modern improvements in technique, results are so satisfactory that a permanent cure is expected. Such being the case, operation is advised unless specially contra-indicated.

**Treatment by truss in adults.**—The only reliable form of truss is one that contains a steel spring to encircle the body and a pad that fits over the inguinal canal, of such a length and fashion that it does not press on any part of the bony pelvis. The common fault in trusses is that they are made too big, resulting in pressure on the bone: the hernia then is not kept up, and the truss is condemned as uncomfortable and inefficient.

Measurements for a truss are taken with a tape measure passing round the body behind, just above the gluteal muscles, crossing the hips between the iliac crests and the great trochanters to the upper margin of the symphysis pubis in front.

The truss is applied with the patient in the recumbent position after the hernia has been reduced. In slight cases the truss is discarded at night, but it is put on before getting up in the morning and not taken off till the last thing at night, lying down in bed. If, however, the hernia descends while the patient is in bed owing to coughing or other reasons, the truss is worn day and night, and only taken off for washing. A hernia treated in this way often disappears for long periods; the patient, thinking it is cured, is tempted to discard the truss. This should not be allowed, for in all probability it will appear again and valuable time will be lost.

**Treatment by truss in infants.**—This offers greater difficulties, but there are corresponding advantages, for there is a chance of a permanent cure. A truss for an infant should contain a light steel spring and have a pad similar in shape to that worn by an adult, but it should be covered with india-rubber for washing purposes. All forms of belts and woollen skeins should be discarded as useless. The truss has to be worn day and night, but needs to be taken off and dried and the baby washed and dried as often as it gets wet; neglect of this rule leads to the formation of sores. It is an undoubted fact that some infants treated in this way are cured, but without dissection it is impossible to say when. As a guiding rule it is best to say that a truss should be worn for at least two years after the last appearance of the hernia. On account of the above-mentioned difficulties in treatment by truss some surgeons are of the opinion that all infants suffering from hernia should be submitted to operation, at whatever age the affection shows itself, and the tendency of the time is rather in favour of this view.

**Treatment by open operation.**—This is the ideal method, for by it a

permanent cure is to be expected; the patient is freed from the annoyance and recurring expense of a truss, and from the danger, however slight, of the hernia getting strangulated. It is therefore recommended in all cases in which there is not some special contra-indication.

FIG. 375.—A double inguinal truss adjusted. (From Eccles's "Hernia.")

The instances in which operation is not indicated are:—

1. Very young infants suffering from gastro-intestinal disturbances, the cure of which may result in the disappearance of the hernia.

2. Old men with weakened abdominal walls—in these the operation is not likely to be successful.

3. Elderly people with a chronic cough, for the same reason.

4. Patients with such an enormous hernia that the abdomen could not contain the protruded viscera if an attempt were made to return them.

**The operation for the radical cure of oblique inguinal hernia.**—The object of the operation is to obtain a permanent cure by cutting down to the sac, returning the contents into the abdomen, removing the sac, and stitching the muscles in such a way that no further protrusion can take place. This is in direct imitation of Nature's method of spontaneous cure.

A very large number of operations have been introduced, and are called by the names of their inventors. For these the student is referred to a text-book on operative surgery; here will be described one operation only which conforms in all essentials with that done by most surgeons.

A 3-inch incision is made, parallel with Poupart's ligament and ½ inch above it, extending from the position of the internal abdominal ring to the external ring: there is no need to carry the incision into the scrotum or labium. The incision is deepened through the subcutaneous tissues until the aponeurosis of the external oblique muscle is reached: this is divided in the line of its fibres along the whole length of the incision, and it is to be noted that this is the only muscle that is cut through. The cord which will then be exposed in the wound is lifted out of its bed, its sheath opened with the knife, and the sac, recognised by its white appearance, dissected out from the constituents of the cord, special care being taken not to injure the vas which lies behind the sac.

The contents of the sac, if any are present, are then returned into the abdomen. The sac, which has been dissected up to the internal ring, is ligatured at its base, cut off, and the stump allowed to retract into the abdomen: this is the essential part of the operation, and care must be taken not to leave a portion of the sac behind.

The next step is the repair of the inguinal canal. This is done by stitching the internal oblique muscle and conjoined tendon down to the recurved edge of Poupart's ligament. Some surgeons pull this muscle down behind the spermatic cord, and others leave the cord in its normal place. In the writer's opinion it does not matter which is done, provided that the entire sac has been removed and that the internal oblique muscle is brought well down over the internal abdominal ring. The incision in the aponeurosis of the external oblique muscle is then stitched up and the skin closed. The suture material may be of silk or catgut; silk is preferable owing to its durability, though the student must remember that the repair does not rest with the suture, but follows adhesions brought about by it.

In the case of an irreducible hernia care must be taken to separate the contents of the sac from the wall. The adhesions that bind the two together may be dense and very firm, and if it is thought that there may be danger of injuring the bowel in separating them it is well to leave a portion of the sac wall adherent to the bowel.

If a large amount of omentum is present it is advisable to remove it. It should be tied by an interlocked suture in such a way as to guard against any bleeding from the stump after it is returned into the abdomen. If bleeding occurs it is most troublesome and dangerous, because the stump retracts at once into the abdomen, and a laparotomy is required without delay.

*Use of silver filigree in large herniæ.*—In the case of a hernia of long standing it may be difficult to repair the inguinal canal in an efficient manner on account of the great stretching that the muscles have undergone and their subsequent atrophy. A number of surgeons have been in the habit of inserting a silver filigree to strengthen and support the tissues. This method is useful in certain cases, but it is open to the objection that the silver wire is a foreign

body, and is apt to cause trouble by suppuration, and has to be taken out at a subsequent operation.

*The use of grafts of tissue in large herniæ.*—This is another method that is coming into favour, and it has the merit that no foreign body is left behind. A graft can be taken conveniently from the ilio-tibial band without impairing

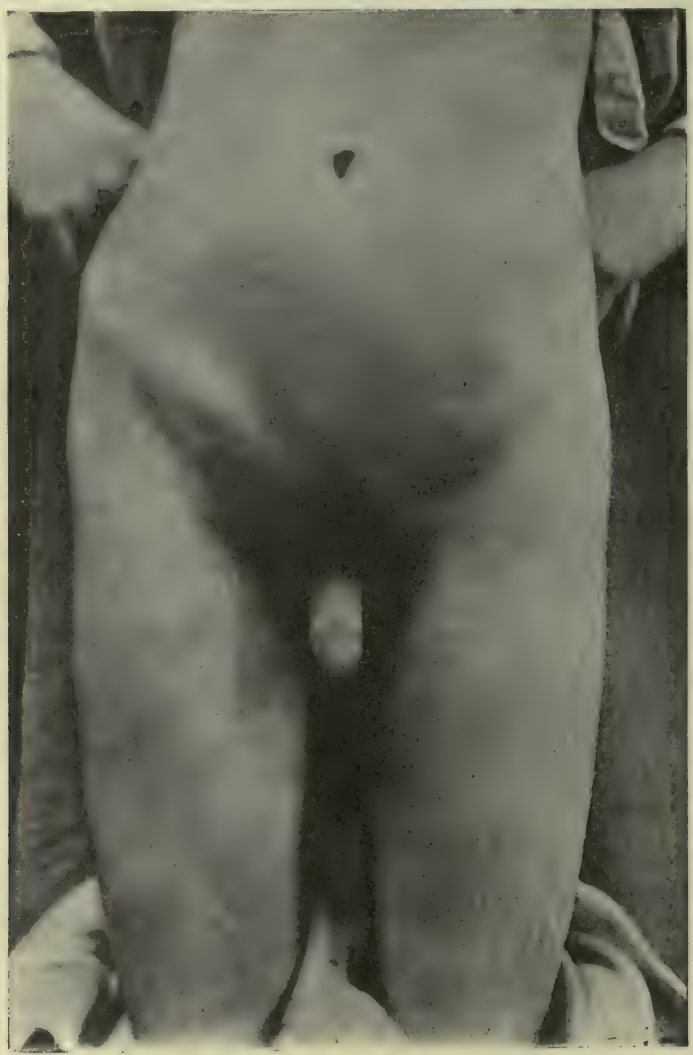


FIG. 376.—A right interstitial hernia with partially descended testis.

the function of the leg. The graft should be laid between the peritoneum and the muscles, the latter being sutured together if possible.

**Hernia associated with partial descent or malposition of the testis.**—The anomalies of the testis are dealt with elsewhere (p. 1108). It is sufficient here to state that a partial descent of the testis is very often accompanied by an incomplete development of the processus vaginalis, and associated in consequence with a hernia. The treatment has to be considered in each

individual case; but as a guiding rule it may be laid down that the hernia is the important factor, and should be treated, whether by truss or by operation, without regard to the testis. The problem of the testis should be considered by itself. If a truss is worn the testis is allowed to look after itself, and as a rule it will slip out of the way and not become pressed on. If an operation is done the question will arise as to whether the testis is to be removed, whether it is to be left alone or whether it is to be pulled down and moored to the bottom of the scrotum. The latter operation is so rarely successful that it is not recommended. If on examination the organ is found to be so ill-developed that it is certain that it will not function, or if it is inflamed from injury, the right course is to remove it. It is difficult to decide this point, and on the whole it may be best to leave it and see what becomes of it later. If it proves a nuisance it can be removed later on, and an additional reason for leaving it is that it will often develop and even descend into the scrotum about puberty.

**Interstitial hernia.**—This is a form of inguinal hernia in which the sac emerges from the internal abdominal ring, but, instead of passing out through the external abdominal ring and descending into the scrotum or labium, turns upwards between one or other of the layers of the abdominal wall, generally between the external oblique and the internal oblique muscles. It is found both in males and females, but in the former is almost always associated with a partial descent of the testis. The reason for this anomaly is that a hernia in its descent takes the line of least resistance, and this is usually into the scrotum, especially when a way has been prepared for it by the previous descent of the testis. If, however, the testis is undescended or the aponeurosis of the external oblique is stronger than usual, the easiest course for it to take may be upwards under cover of that structure. There is no essential difference in the treatment of this condition, except that if a truss is worn the shape of the pad has to be different. An operation should be advised unless there are strong contra-indications. There is no essential difference in the operative procedure between this form and the ordinary inguinal variety.

## Femoral Hernia.

**General description.**—Next to inguinal hernia this is the commonest variety met with. The hernia passes out of the abdomen through the crural canal and emerges in the thigh through the saphenous opening. Thence its course depends on the line of least resistance: in the majority of cases it turns upwards again on to the abdomen, passing superficially to Poupart's ligament; more rarely it tracks down the thigh, lying parallel to and on the inner side of the femoral vessels.

**Surgical anatomy.**—The crural canal is the innermost of the three compartments of the femoral sheath. It is a narrow interval between the femoral vein and the inner wall of the femoral sheath, and only exists as a space when separated from the vein by dissection or by pressure of a hernia. Its important relations are—the femoral vein, on the outer side, from which it is separated only by a thin, fibrous septum; Poupart's ligament, which helps to form the anterior wall; and Gimbernat's ligament, on the inner side. It is against the sharp edge of Gimbernat's ligament that a femoral hernia becomes strangulated, and it is this structure which has to be divided in the operation of herniotomy. Occasionally the obturator artery, when abnormally placed, skirts along the greater part of the circumference of the femoral ring, and may be injured during division of Gimbernat's ligament. Formerly this was

a sort of bugbear to surgeons, but now it has no terrors, for if wounded it can be picked up easily and ligatured.

*Relation to age and sex.*—Femoral hernia is nearly three times more common in women than in men, probably because the pelvis is wider and Gimbernat's ligament is less strongly developed in the former; also the fact of child-

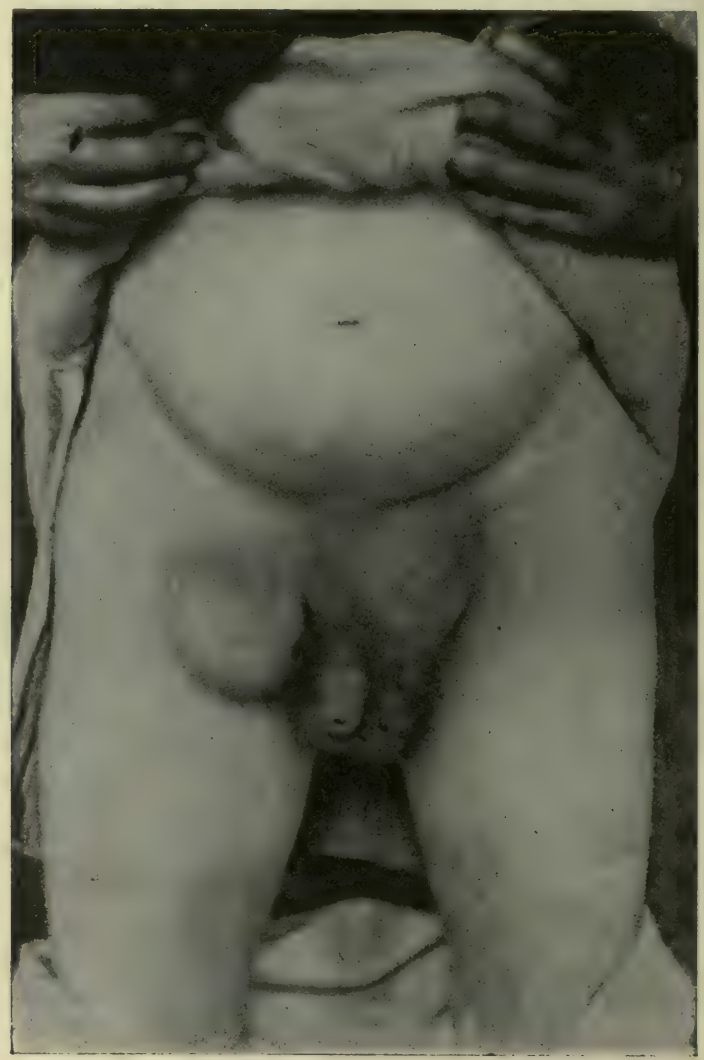


FIG. 377.—A right femoral hernia passing down into the thigh.
(From Eccles's "Hernia.")

bearing seems to have a predisposing influence on its development. Though it is more common to find a femoral hernia in a woman than a man, it must not be supposed that all herniæ in women are femoral, for the fact remains that even in women the inguinal variety is still more common than the femoral.

Femoral hernia is very rarely seen in either sex before the age of puberty.

This is one of the reasons brought forward against the congenital theory of development of femoral hernia, and, as Prof. Keith points out, a diverticulum of peritoneum in the femoral canal is never seen at birth.

*Relation to occupation.*—In men certain trades seem to predispose to femoral hernia, namely, those of bakers, gardeners, and stokers. As a rule the men who are affected are small, wizened, and of poor muscular development. Women, on the other hand, are very often fat.

**Diagnosis of femoral hernia.**—The onset of femoral hernia is generally insidious and painless. It forms a swelling lying below Poupart's ligament in the upper and inner part of Scarpa's triangle and to the outer side of the spine of the os pubis. It is often mistaken for an inguinal hernia, but should not be so if only a little care is taken in defining Poupart's ligament, which can be done even in the fattest of patients. Very commonly the fold of the groin is taken for Poupart's ligament; it should be observed that these two do not coincide, the fold in the groin lying below and more horizontally than the ligament.

**Differential diagnosis.**—Femoral hernia is to be distinguished from:—

1. Other swellings with an impulse of coughing:

(*a*) *Inguinal hernia.*

(*b*) *Saphena varix.*—Here there is a soft swelling in the saphenous opening, which gives a fluid thrill on coughing rather than a definite impulse. It is easily reducible by the lightest pressure of the finger, the swelling reappearing at once as soon as the finger is removed. The condition also is almost invariably associated with varicosity of the veins of the leg.

(*c*) *Psoas abscess* pointing below Poupart's ligament.—An abscess in this position will be reducible and give an impulse on coughing; generally the abscess will point above Poupart's ligament as well, and there may be well-marked signs of spinal disease.

2. Solid swellings:

(*a*) *Enlarged or inflamed lymphatic glands.*—The same remarks as are mentioned in the differential diagnosis of inguinal hernia (see p. 907) are applicable here.

(*b*) *Innocent tumours, e.g.*, lipoma and fibroma.

(*c*) *Malignant tumours, e.g.*, sarcoma.

**Treatment of femoral hernia.**—As in inguinal hernia, the only choice of treatment is between wearing a truss and operation. Of the two the latter is certainly preferable, and it becomes imperative when the hernia is large and irreducible and when it cannot be controlled by a truss.

The measurements for a femoral truss are taken in the same way as for the inguinal. The truss also should have a steel spring encircling the body, but the pad has to be inclined at a greater angle to the line of the spring in order to bring it over the position of the saphenous opening. If the hernia is at all large and difficult to control, a belt which passes round the thigh has to be attached to the apex of the pad so as to help to keep the latter in position during changes of posture. Irreducibility is not necessarily a bar to the application of a truss, for the pad may be hollowed out so as to fit over the protrusion; unless specially contra-indicated, however, operation should always be advised.

**Treatment of femoral hernia by open operation.**—A vertical incision is made over the swelling and deepened through the subcutaneous tissues until the sac is reached. This is pulled up and separated completely from the

surrounding tissues until the neck protruding from the femoral canal is exposed. The sac is opened and the contents returned into the abdominal cavity. Traction is then exerted upon it and a ligature applied as far up as possible. The end of the sac is cut off and the stump pushed up into the abdomen. The femoral canal is closed by passing two or three sutures

FIG. 378.—A right femoral truss adjusted. (From Eccles's "Hernia.")

between that portion of Poupart's ligament which forms the anterior boundary of the ring and the pectineal fascia covering the pectineus muscle.

In some instances, especially when the hernial aperture is a large one and approximation of its walls is impossible, it may be advisable to cut a flap of pectinea fascia, or even of the pectineus muscle itself, and stitch it across the femoral ring.

The operation as described is not eminently satisfactory, because it leaves the upper end of the femoral ring unclosed, and allows the possibility of a piece of omentum or bowel getting into and distending it, and so favouring a recurrence of the hernia.

To obviate this the method of closing the canal by driving steel staples through the anterior wall of the femoral ring into the pubic bone was devised. This is unsatisfactory, and is to be deprecated on account of the subsequent pain. During the last few years there has been introduced a method of exposing the neck of the sac extraperitoneally immediately above Poupart's ligament, pulling the sac of the hernia through the femoral ring, and then closing the ring entirely by a couple of sutures which approximate its anterior margin to the strong tendinous fascia attached along the length of the ilio-pectineal line. This has the merit of closing the ring completely and not leaving a small pouch, into which a piece of bowel or omentum might protrude and give rise to a recurrence of the hernia.

## Umbilical Hernia.

**General description.** This is a protrusion through the weak spot in the centre of the abdomen where the umbilical cord was attached, and which is closed by scar tissue.

Umbilical hernia is found commonly in young infants and in obese adults. There is also a rare form (*exomphalos*) in which there is a protrusion of the viscera into the umbilical cord at birth, and in which, if the condition is not recognised, there is danger of the bowel being tied in with the cord. It is very difficult to save subjects suffering from this condition from dying even if it is recognised, for the tissues are so thin, and ulceration so apt to occur, that most of them succumb to septic peritonitis.

Fig. 379.—Umbilical hernia, showing the attenuated condition of its covering. (St. Bartholomew's Hospital Museum.)

**Umbilical hernia in infants.**—This is a very common occurrence on account of imperfect cicatrisation of the umbilical scar, associated with increased intra-abdominal pressure resulting from straining or distension of the intestines. The hernia forms a button-like protrusion at the navel, is easily reducible with the finger and rarely gives rise to any symptoms, the patients usually being brought for treatment on account of the swelling.

*Treatment.*—This is simple, and in the vast majority of cases results after a few months or years in a permanent cure. All factors likely to give rise to abdominal distension are to be guarded against, and in the opinion of some surgeons this is sufficient, as little more than the removal of the cause is likely to bring about the termination of the trouble. It is, however, generally advisable to apply some form of support in order to bring about the desired end more quickly. An old and simple method is to apply a round metal disc or coin to the umbilicus and secure it in position with a binder. It is better to advise the application of a steel truss with a circular flat pad which is worn day and night; it is much more efficient. It is a mistake to use a pad with a

conical protuberance in the centre with the idea that this will cause pressure on the umbilicus and hasten the cure; the pad in this instance is likely to cause atrophy of the part and retard the cure.

In a small number of cases the umbilical hernia is associated with some

FIG. 380.—Umbilical truss adjusted. (From Eccles's "Hernia.")

divarication of the recti. This requires rather longer treatment, but of the same nature.

If the hernia is not cured by these methods an open operation is called for. The operation is simple: an incision is made round the swelling, the peritoneal sac dissected up and ligatured, and the walls of the ring brought together by sutures.

**Umbilical hernia in adults.**—Umbilical hernia is rarely found in adults before the age of thirty. It is found both in men and in women, but especially

in the latter when they are fat and their abdominal walls have been weakened by child-bearing.

*Symptoms and signs.*—The swelling generally appears slowly and insidiously, and it is only when it attains a large size that patients complain of pain and dragging sensations in the abdomen. There are often associated symptoms of indigestion and flatulence.

The hernia forms a rounded or oval swelling, with a great tendency to sag down towards the symphysis. It is almost always irreducible, often lobulated, and may attain to a very large size.

*Prognosis.*—An umbilical hernia is not one that can be neglected, for on account of its large size, its frequent irreducibility and its exposed position, it is liable to become inflamed and obstructed. Strangulation, too, is not infrequent, and when it occurs is very dangerous.

*Treatment of umbilical hernia in adults.*—As in other forms of hernia, the treatment is palliative and radical or operative. It is not very satisfactory by either method. In the first case wearing a truss does not cure the hernia, and also, owing to the frequent irreducibility, it may not retain it efficiently; an umbilical hernia may become strangulated even when a truss is being worn. On the other hand, corpulent patients, suffering as they often do with renal disease and fatty hearts, are not good subjects for operation. The abdominal walls, too, are often weakened, and a cure cannot be expected with the same confidence as in either the inguinal or femoral varieties.

**Treatment of umbilical hernia by open operation.**—The sac is freely exposed by a vertical or transverse oval incision and dissected from the surrounding integuments. The contents of the sac are returned into the abdomen, considerable difficulties often arising on account of adhesions. The peritoneum is then sutured and an estimate made of the possibility of approximating the edges of the aperture left. The edges of the gap are brought together by one or more rows of sutures arranged either in a vertical or a horizontal manner.

The objection to this operation is that it is imperfect, because at the seat of pressure there will be only fibrous or scar tissue to withstand the strain, and this is likely to give and allow the hernia to form afresh. An attempt is often made to strengthen the line in one way or another. One method is to make the two recti muscles overlap in the middle line; another is to take a flap from the anterior sheath of the rectus on either side and unite them across the middle line. Fascial grafts are also used.

Even after an operation has been done it is often advisable to recommend some form of abdominal support, especially when the patient is very stout.

It may be noted here that an abdominal belt, so beloved by patients because it supports a pendulous abdomen, is of very little use in keeping up an umbilical hernia.

**Divarication of the recti** is of common occurrence, both associated with an umbilical hernia and without it. It is found most frequently in women who have had a number of children, and is often a great inconvenience to them.

When the patient is lying down with the muscles at rest nothing is seen of this, but as soon as the head is raised or the abdominal muscles are brought into play the abdominal contents bulge in a more or less vertical line and form a sort of rounded ridge. This is associated with a loose attachment of all the abdominal viscera, and much of the abdominal contents, including the liver, may be protruded at the same time.

The treatment by open operation is unsatisfactory, and it is better as a rule to advise the application of a belt, or of a belt and umbilical truss combined.

The symptoms complained of are dragging pain and colicky sensations.

## Ventral Hernia.

This term includes those herniæ other than inguinal, femoral and umbilical which pass through the anterior abdominal parietes. They may be divided into :—

1. Hernia through the linea alba.
2. Hernia through the linea semilunaris.
3. Traumatic or operative hernia, which may occur wherever an incision has been made.

**Hernia through the linea alba.**—The linea alba is formed by the interlacing fibres of the aponeuroses of the oblique and transversales muscles. It is narrow below the umbilicus, but broadens above where the recti muscles diverge from one another in their ascent, and it is in this portion that a hernia is most often found. It is not at all uncommon for a small piece of subperitoneal fat to be herniated through a gap in the interlacing fibres of this structure, and as this increases a small pouch of peritoneum is pulled after it. In it some portion of the intestine or omentum may be found. Such a hernia rarely gives rise to much trouble, nor does it attain a great size.

Its treatment must be carried out on the lines laid down for the treatment of an umbilical hernia. A truss is applied, or if this proves unsatisfactory an operation is done and the gap sutured.

**Hernia through the linea semilunaris.**—A hernia in this situation is rare except below the level of the umbilicus. As has been stated before, the form known as a direct inguinal hernia really comes through the linea semilunaris.

This form of hernia emerges from the abdomen through Hesselbach's triangle, that is, between the deep epigastric artery and the outer edge of the rectus muscle. It enters the lower part of the inguinal canal, lying above and to the inner side of the spermatic cord, and emerges at the external ring. It will be realised, therefore, that the course of this hernia is direct as compared with the oblique form. It is, however, often not easy to distinguish between the two without dissection. An oblique inguinal hernia of old standing comes to appear direct when the rings, from stretching, lie almost one in front of the other.

It is most often found in elderly males, and forms a more or less rounded swelling, rarely reaching the scrotum. If the sac is invaginated with the finger it is sometimes possible to feel the deep epigastric artery pulsating on the outer side of the aperture instead of the inner, as in the oblique inguinal variety.

The treatment is the same as in the oblique form, but in the case of operation it must be remembered that the sac is not incorporated with the spermatic cord, and that it is not so easy, from want of material, to repair the hole, which may be a large one.

**Traumatic ventral hernia.**—This is the result of any operation or injury in which the muscles have failed to unite, either from want of sufficient care in approximation or suture, from suppuration, from the insertion of a drainage tube, or from division of nerves. It is particularly liable to be found after the operation for the evacuation and drainage of an appendix abscess.

The hernia takes the form of a diffuse bulging, which increases when the patient stands up, and may be the cause of the very greatest pain, incon-

venience and incapacity. If nerves have been cut, a large portion of the abdominal wall may bulge in a similar way.

The real treatment is to prevent such a hernia forming by careful incision of the abdominal wall, by avoiding cutting across a muscle, and by careful closure of a wound layer by layer.

If, however, a hernia has developed, it is best treated by an operation which consists of closing the gap in the muscles in their proper order after a dissection of the part has been made. If there is insufficient tissue to close a big hole, a graft of fascia may be employed.

If none of these methods are practicable, a suitable belt or truss has to be applied.

### Lumbar Hernia.

Between the last rib and the crest of the ilium is a weak spot in the abdominal wall, bounded by the anterior edge of the latissimus dorsi and the posterior edge of the external oblique and known as the triangle of Petit. In rare instances a hernia protrudes here, forming an ill-defined bulging.

It is not uncommon to find a traumatic lumbar hernia in this situation following operations on the kidney. If the nerves to the oblique muscles have been divided one often finds in addition considerable yielding of all these muscles. The hernia is best controlled by a truss or belt.

### Obturator Hernia.

An obturator hernia is one that escapes through the obturator canal, *i.e.*, the aperture in the obturator membrane for the passage of the obturator vessels and nerve. The neck of the sac is bounded by the horizontal ramus of the os pubis above and by the sharp edge of the obturator membrane at the sides and below; the fundus of the sac either pushes the obturator externus muscle in front of it, or passes above that muscle or between its fibres, and comes in contact with the pectineus; it gives rise to a slight fulness in the upper part of the thigh just below Poupart's ligament and immediately behind and internal to the femoral vessels.

The sign that might be expected from such a hernia would be that due to pressure on the obturator nerve, namely, pain down the inner side of the thigh and knee: as a matter of fact it is very rarely diagnosed unless it becomes strangulated, and is then only found when the abdomen is opened and the hernia seen from the inside. Even if it is recognised, it can only be dealt with from within. The pelvis is elevated, the intestines packed back, the hernia withdrawn, and then the obturator ring sutured.

A **sciatic** or **gluteal** hernia is another very rare form of hernia which protrudes through the great sciatic notch either above or below the pyriformis muscle. It forms a tense resonant swelling which bulges the buttock, obliterating the gluteal fold and yielding an impulse on coughing. It has to be distinguished from an abscess which emerges from the pelvis through the sciatic notch and forms a swelling under the gluteal muscles. When such an abscess contains gas the resemblance to a hernia is very close. Whether strangulated or not, it is best dealt with by abdominal section, the external operation offering great difficulties owing to the depth.

### Perineal, Rectal, and Vaginal Herniæ.

These form occasional varieties of prolapse of the pelvic organs, especially of the uterus.

The **perineal** hernia in the female is an elongation downwards of Douglas's pouch, and protrudes between the vagina and the rectum. In the male a hernia may follow an ectopic testis.

The **rectal** and **vaginal** forms protrude respectively into these cavities, pulling down the bladder. They are best treated as for prolapse of the uterus.

## Diaphragmatic Hernia.

This form does not give rise to any external swelling, because the abdominal viscera are protruded into the cavity of the thorax; yet it is a true hernia, and is included, therefore, in this section.

*Causation.*—This may be divided into *congenital* and *traumatic.*

In the congenital form a proper sac of peritoneum is formed which protrudes through a gap in the fibres of the diaphragm. More often, however, the hernia follows some injury, such as a gun-shot wound. It is most likely to occur on the left side, and the hernia causes displacement of the heart to the right side and interference with the proper breath sounds on the left side of the thorax. The condition can be diagnosed with the help of a skiagram.

*Treatment* is unsatisfactory because of the difficulty of replacing the viscera in the abdominal cavity and of closing the gap in the diaphragm. If an operation has to be done it is best carried out through a trans-pleural incision.

## Hernia of Special Viscera.

**Hernia of the cæcum.**—This organ may be found in an inguinal hernia, either right or left-sided, or in a femoral hernia. If it has entered a sac on account of an unduly long meso-cæcum, there is no special mention required for its treatment. Notice is necessary, however, of an anomaly known as "sliding hernia of the cæcum." In this form the peritoneum covers the cæcum only on its anterior and lateral surfaces, the posterior wall being in direct contact with the tissues surrounding the hernia. The clinical features do not differ from those of the usual form, the interest coming during the operation for the cure. Care must be taken in opening the sac lest the organ be injured. The repair of the sac also offers difficulties, for it is impossible to tie it off in the usual way, the posterior wall being formed by the cæcum. The anterior part of the sac has to be dissected up as usual, and the posterior wall of the cæcum freed from underlying tissues so that it can be returned into the abdominal cavity. The long slit in the peritoneum has then to be sewn up and the muscles brought over it: in other words, the cæcum is made to slide up and to retrace its downward course.

The pelvic colon may present itself in a similar way, though less frequently, in a left inguinal hernia.

The vermiform appendix, which as a rule accompanies the cæcum, needs no special mention except to note that it may become inflamed, and even gangrenous, while it is an inmate of a hernial sac.

**Hernia of the ovary.**—The ovary accompanied by the Fallopian tube is usually protruded through the patent processus vaginalis (or canal of Nuck). It is felt in the inguinal canal as a small oval, solid body which is distinctly tender on touch, and it is noticed that the swelling increases at the menstrual periods.

It is best treated by operation and the ovary replaced in the abdominal cavity. Even if it is small and apparently ill developed, it should not be removed unless markedly cystic.

**Hernia of the urinary bladder.**— In the event of great hypertrophy and distension of the bladder owing to a stricture or enlargement of the prostate, the effort of straining to empty it may cause some displacement of the organ, and it may pass into an associated inguinal, or more rarely a femoral, hernia.

As a rule the situation is not detected until an operation is done upon the hernia, and for this reason there is some danger of the organ being injured. It forms a swelling in the inguinal region, is soft and fluctuating, and has been mistaken for, and tapped as, a hydrocele of the tunica vaginalis or of a hernial sac. The most distinctive sign is that the swelling can be emptied or is lessened by the act of micturition, and that pressure on the hernia brings on a marked desire to pass water.

*Treatment.*— If the bladder is discovered accidentally in the course of an operation on a hernia, it should be replaced and the hernia treated in the usual way. If it has been included in a ligature or accidentally punctured, the ligature must be removed and the bladder wall carefully sutured. Most accidents of this sort have occurred owing to neglect of the fundamental rule that the hernial sac should never be tied off unless it has been opened and the surgeon has satisfied himself that all the contents have been returned.

## Hernia in relation to the Public Services and Civil Employment.

The presence of a hernia debars an applicant from entrance to most of the public services, such as the Army, Navy, and Civil Service or Post Office, and this is a strong argument in favour of the operative treatment of hernia in whatever form it is found.

During the last few years, in addition, the employers of large works and factories have instituted a medical examination of their workpeople before engagement, and rejected those suffering from hernia on account of the fact that under the Employers' Liability Act they have to pay compensation for any *employé* who develops a hernia during his work, whether it can be proved to be of congenital origin or not.

Such patients after a successful operation for radical cure are accepted, and a large number of persons applying at hospitals for the relief of hernia request an operation on these grounds.

# Section XXII.

## SURGERY OF THE STOMACH AND DUODENUM.

### Injuries of the Stomach.

Owing to its protected position, the stomach is tolerably immune from casual injury, but it may be bruised or even ruptured by external violence applied to the body wall over it, or it may be penetrated by stabs or bullet wounds. The commonest injury to which it is liable from within is corrosive poisoning, the cicatricial *sequelæ* of which may call for surgical intervention. The damaging effects of edged or pointed foreign bodies which have been swallowed are dealt with under a separate heading.

**Contusion and rupture.**—The stomach, especially when full, may be bruised or even ruptured by a blow without any evident injury to the abdominal wall. The symptoms produced by such an injury vary very much, but they are almost always associated with a certain amount of collapse, the difficulty being to ascertain whether such collapse is due to interference with the solar plexus, hæmorrhage, or the escape of stomach contents. Vomiting is common, and if blood is present this may be an aid to diagnosis. In accidents from being run over, other viscera, such as the liver and spleen, are commonly injured, and there will be evidence as well of internal hæmorrhage. The differential diagnosis between rupture and non-rupture, and indications for operation will be found under the heading *Injuries of the Abdominal Parietes* (p. 874).

**Penetrating wounds from without.**—The immediate danger attending penetrating wounds which involve the stomach is hæmorrhage from a wounded artery in the parietes or the stomach wall itself. The remote danger is infection of the peritoneum either through the external wound (or the agent which inflicted it) or in consequence of the escape of gastric contents.

The *treatment* is always the same; the abdomen should be opened at once, whether there is evidence of serious injury or not, the damage, if any, repaired, and the abdominal wall sutured.

**Injuries from corrosive poisoning.**—When a strong corrosive acid or alkali is swallowed the effect is most marked along the lesser curvature of the stomach and at the pyloric end. A corrosion sufficient to cause sloughing is usually rapidly fatal; hence these cases rarely come into the domain of surgery. If, however, the patient survives the initial injury, adhesions and contractions may result in the partial occlusion of the stomach and of the pylorus, necessitating the performance of a gastrostomy or gastroenterostomy, according as to whether the inlet or outlet of the stomach is affected.

**Foreign bodies in the stomach.**—The commonest foreign bodies which are swallowed accidentally are coins, tooth-plates, nails or pins. In the stomachs of jugglers, thieves, and the insane the most varied collection of objects have been found, including knives, forks, and spoons. Should the article be small and rounded, such as a coin, it will usually pass without difficulty, and it is astonishing how irregular objects, even with sharp points, such as a tooth-plate, often pass safely through the intestines without causing any disturbance.

In such an instance neither purgatives nor opiates should be given; both are injurious—the purgative by increasing the chance of the bowel being injured by the projecting points, and the opiates by arresting its progress. The better plan is to keep the patient quietly in bed and administer a large quantity of pultaceous food, while skiagrams are taken from day to day to watch the progress of the object. If the foreign body lodges in the stomach and begins to cause irritation, as evidenced by pain and vomiting, or if the skiagram shows that it has not passed out of the stomach, then the correct course is to open the abdomen, incise the stomach, and extract it, the stomach being subsequently sutured. The operation is a successful one, and can be performed with very slight risk to the patient, whereas the risks from perforation and peritonitis are great if a foreign body is left and ulcerates its way through the stomach. Balls of hair of astonishing size collect in the stomach; they are found in the insane and in people who acquire the habit of biting off the ends of their hair and swallowing them. The diagnosis is generally made only when the stomach is opened.

FIG. 381.—Hair ball from the stomach. (From a photo kindly lent by Mr. G. P. Newbolt.)

## Diseases of the Stomach.

The chief diseases which the surgeon is called upon to treat are peptic ulcer, with its many attendant complications, and malignant disease of the stomach. In this branch the border-line between medicine and surgery is so close that it becomes imperative that there should be an active co-operation between the physician and surgeon for their mutual help and guidance. In the treatment of the various conditions many difficulties arise, but in their diagnosis there are even more, on account of the inefficiency of our present methods of examination. It is hoped that with increasing knowledge it may soon become possible to differentiate with exactitude between gastritis and gastric ulcer, and to diagnose a carcinoma while still in the early stages and amenable to treatment.

**Methods of examination.**—The following are the chief methods employed in the examination of a stomach case :—

1. **A careful history** is obtained from the patient dealing with pain, flatulence and vomiting associated with the taking of food, and an inquiry as to any attack of hæmatemesis or melæna.

2. **Physical examination of patient.**—This involves a very complete examination, and should include observations concerning the presence of anæmia or alteration of the constituents of the blood, a careful examination of the lungs (phthisis often causes symptoms which lead patients to think they have some gastric trouble), and the nervous system (gastric crises of tabes have been mistaken for evidence of gastric ulcer). The stomach also should be inspected for evidence of undue peristalsis and palpated for tenderness, resistance or a tumour, and percussed with a view to finding out whether it is dilated or not.

3. **Examination of the stomach contents.**—This is done by means of a test meal, which should consist of one pint of tea (without milk or sugar) and 2 oz. of dry toast, given on an empty stomach and syphoned off by means of a soft rubber stomach-tube forty minutes to an hour afterwards. The fluid drawn off is a rough indication of the extent of digestion and the amount that has passed through the pylorus in a given time. The investigation is then directed to the following points :—

(*a*) *Microscopical examination* for blood cells, starch granules, sarcinæ, yeast cells and the Oppler-Boas bacillus. In the normal stomach with active digestion the gastric juices destroy most moulds and organisms which are taken with the food ; if, however, there is some considerable derangement of the stomach and the passage of food is delayed, fermentation goes on, and a large quantity of sarcinæ, yeast cells, and other organisms are found. The Oppler-Boas bacillus was thought to be an accurate indication of the presence of malignant disease, but this is not the case, for it is found in cases of fibrous stenosis of the pylorus just as frequently.

(*b*) *Chemical analysis.*—The importance of this test lies in the relative proportion of active or free hydrochloric acid to the mineral chlorides. Physiologically active hydrochloric acid, secreted by the oxyntic cells of the stomach, is present in the stomach either as a free mineral acid or combined with protein. The proportion that this acid bears to the mineral acids (which are sodium and calcium chlorides derived from the gastric juice) is in a normal stomach as 150 : 100. In carcinoma of the stomach the amount of active hydrochloric acid is greatly diminished, whereas in gastric and duodenal ulcers it is greatly increased, so that in the latter two instances the proportion may be as much as 300 : 100. Combined with all the other signs and symptoms this test is of great value, though, like all other tests, it is not infallible.

4. **Examination of the fæces.**—The patient is put on an appropriate diet, and subsequently an examination of the fæces made by the benzidine test for the presence of occult blood. A positive result indicates an open ulcer in some portion of the alimentary tract.

5. **Examination with the X-rays.**—This method is a valuable adjunct in the examination of a stomach, and is always to be employed when possible. The patient is first given a bowl of rice pudding or milk containing bismuth nitrate or one of the insoluble barium salts. By the use of the screen a dark shadow can then be seen indicating the position of the bismuth and hence the position of the stomach : by observation for a short time the position and motility of the stomach can be gauged, and the length of time

the stomach takes to empty itself noted. This method's chief use is in cases of mechanical obstruction of the pylorus associated with gastric dilatation.

6. **Optical methods.**—An attempt has been made during the last few years to fashion a gastroscope for examining the interior of the stomach in a similar way to that employed for the bladder with a cystoscope. The method presents many difficulties and is not yet perfected, and some surgeons think that it is inadvisable to introduce in every case a long and rigid tube so far into the stomach as to reach the pylorus.

7. **Laparotomy.**—The final method of diagnosis, and probably the best, is made by opening the abdomen and submitting the stomach to a close inspection. Even with that organ between the fingers it is not always easy to come to a definite conclusion, for a gastric ulcer may be present without showing any evidence such as scarring on the peritoneal surface, and even if a thickening is felt, it may be impossible to state whether it is malignant or not without cutting out a piece and submitting it to histological examination.

## Gastric Ulcer.

*Etiology.*—The exact reason for the development of a gastric ulcer is not very clear. It would appear that it is due sometimes to a thrombosis of one of the smaller arteries, whereby a portion of the mucous membrane, weakened and deprived of its blood supply, is digested by the gastric juices—though why the thrombus should form originally is not certain.

According to the extent of the thrombus, the ulcer formed may involve the superficial portion of the mucous membrane or the whole thickness of the stomach wall, resulting, when that portion is digested, in a perforation. The ulcer, which is usually round or oval, may be single or multiple, and the usual situation of that form which is liable to perforate is in the neighbourhood of the pylorus on the anterior surface, and nearer the lesser than the greater curvature. In an ulcer of long standing a great deal of fibrosis forms about it, leading to a heaped-up condition of the walls, and, if the inflammation spreads to its base, the peritoneum covering it becomes opaque and puckered and acquires adhesions to neighbouring viscera. The acute form is common in young anæmic girls of from seventeen to twenty years of age. The chronic form is seen more often in adults about the age of forty.

*Results of gastric ulcer.*—Under favourable conditions the ulcer heals, leaving an inappreciable scar on the mucous surface. If the inflammation is extensive enough to reach the peritoneum, local peritonitis is set up, with adhesions to adjacent viscera, or cicatrisation and deformity of the stomach, resulting, it may be, either in fibro-stenosis of the pylorus and dilatation, or, if the ulcer is situated in the body of the stomach, in an "hour-glass" contraction. In severe instances, with extension of the ulcerative processes, a non-thrombosed vessel is eroded, resulting in hæmatemesis or melæna, or the stomach wall is actually perforated, allowing escape of the gastric contents. If the perforation is not promptly dealt with, local or general peritonitis, depending upon the situation of the ulcer and the resistance of the individual, follows.

**Gastric ulcer without complications.**—Pain is a prominent symptom, and is closely associated with the ingestion of food, coming on shortly after a meal and lasting a variable time; it may be only slight, or so intense that the patient is afraid to take food for fear of exciting it. The pain is situated usually at the xyphoid appendix or under the left costal margin, and may be referred to the back between the shoulder-blades. There is often local

tenderness or acute pain, with hypersensitiveness of the skin at one spot. Vomiting is not an invariable feature, but is often found, and when it occurs generally relieves pain. Some information may be got from the examination of the vomited material, minute traces of blood being found and the amount of active hydrochloric acid increased.

*Treatment.*—If there are no complications, the treatment, at any rate at first, should be medical, the patient often being cured by rest in bed with appropriate diet and nursing. If, however, medical methods have been tried for a period of two or three months and have failed, it may become advisable to resort to surgery. There are three available methods of surgical treatment: —(1) Excision of the ulcer or ulcer-bearing area; (2) inversion of the ulcer and suture of the stomach; (3) gastro-enterostomy, so as to allay the irritation of the constant passage of food over the ulcer and to put the stomach at rest.

Fig. 382.—Gastric ulcer erodin · the splenic artery. (St. Bartholomew's Hospital Museum.)

Which of these methods should be undertaken can be decided only after the abdomen has been opened and the stomach explored. The presence of an ulcer may be obvious at once from thickening, scarring, and puckering of the peritoneum, but no such evidence may be forthcoming, either because the ulcer has not affected the peritoneum or is concealed from view on the posterior surface or cardiac end of the stomach. If the ulcer is obvious and is situated in such a position that it can be excised and the stomach-wall afterwards sutured without unduly narrowing the lumen, this method is the most radical and probably the best; more often this is hardly possible, the ulcer being situated near the pylorus or on the posterior surface of the stomach. Then gastro-enterostomy is advised, provided that the opening is on the proximal side of the ulcer, the idea being that drainage of the stomach in this position will prevent the passage of food over the surface of the ulcer and so allow it to heal. The results of gastro-enterostomy are not invariably good, pain often persisting, and the patient preserving dyspeptic symptoms and still needing to be dieted with great care. Simple inversion of the ulcer is rarely used except in cases of perforation.

**Treatment of gastric ulcer associated with hæmatemesis.**—Hæmatemesis is a grave and alarming complication of gastric ulcer, the patient often losing several pints of blood, and, if the hæmatemesis is continued, becoming blanched and excessively weak in consequence. The opinions of surgeons are somewhat

divided as to the correct treatment in such a case. The available methods are :—(1) *Non-operative.*—In this instance the taking of any food by mouth is prohibited. Opium is administered to diminish blood pressure and allay restlessness, while the great thirst of which the patients nearly all complain is alleviated by rectal enemata. (2) *Operative.*—These may be (*a*) gastrotomy and ligature of the bleeding point ; (*b*) excision of the ulcer or ulcer-bearing area ; (*c*) gastro-enterostomy. It must be remembered in the first instance that a patient after a great loss of blood is not a good subject for any operation, however slight, and a laparotomy under such conditions may prove fatal. Further, actual death due to loss of blood from an ulcer is found to be extremely rare, spontaneous clotting tending to occur when the patient becomes faint from loss of blood. On the other hand, a surgeon is tempted to operate, feeling that any further loss of blood might be fatal and that some attempt should be made to stop it at all costs. If it were known where the ulcer was situated, and also that it was easily accessible and that the bleeding point could be picked up or the ulcer excised, this might be the right course to adopt. As a matter of fact, these points are not known, and the operation, even if possible, is a severe one ; it may not be feasible at all, either because the ulcer is situated near the cardiac end of the stomach or on the posterior wall. Statistics tend to show that the results of operating under such conditions are worse than when the patients are left alone and prohibited from taking any food by mouth. In the writer's opinion fewer patients are lost by adopting this expectant rather than the operative treatment. If, as is usual, the patient recovers from the bleeding, then later, when the loss of blood has been made up, a gastro-enterostomy may be done to put the ulcer at rest and give it an opportunity to heal. At this stage the operation is one of no great risk.

**Gastric ulcer with perforation.**—The characteristic symptom of perforation is sudden agonising pain in the epigastrium, associated with great collapse of the patient. Symptoms of chronic gastric ulcer or dyspepsia may have been present previously, but, as is often the case, the perforation may be the first indication of any trouble The collapse may be very severe, with a subnormal temperature and a slow, feeble pulse, and then as the shock passes off the pulse-rate and temperature rise. Vomiting is not usual ; it may occur once, and then not reappear until the onset of peritonitis excites it The abdomen is at first retracted and as hard as a board ; in the course of an hour or two, as the shock passes off, the abdomen becomes more natural, but rigidity of the upper half of one or both recti muscles usually remains ; finally, it gradually becomes distended and tympanitic. Liver dulness may disappear, but this sign is of no great value, as it may be due to mere distension of the colon. Later on all the signs of peritonitis set in (see p. 884). The condition has to be diagnosed from colic, perforation of other viscera, such as the duodenum or the appendix, and a ruptured ectopic gestation. If there is any doubt as to the diagnosis the abdomen should be opened, for the risks attending an unnecessary laparotomy are but slight when compared with those of a neglected perforation.

*Treatment.*—This is undoubted. Laparotomy and suture of the ulcer is called for at the earliest possible moment. If this can be done a few hours after the perforation has occurred the results are very satisfactory, but if delayed peritonitis may prove fatal. The abdomen is opened in the middle line above the umbilicus, when free gas is usually noticed in the peritoneal cavity, and also in some cases stomach contents. The first thing to do is to seek for the perforation, which is usually small, clean-cut, and situated on the

anterior wall of the stomach near the pylorus. If not seen there, the stomach is turned up and a search made on the posterior surface. When found, the edges of the ulcer are inverted and the peritoneal coats brought into contact over the hole with a double layer of Lembert's sutures. If the perforation is close to the pylorus and the necessary suturing causes narrowing of the pyloric orifice, it is advisable to perform a gastro-enterostomy as well. In certain instances it is found impossible to close the perforation by inversion as described owing to thickening and stiffening of the stomach resulting from long-continued inflammation and fibrosis, which cause the sutures to cut out. In such a case the hole is closed by bringing up a piece of omentum and stitching it firmly to the stomach, when adhesions, which form rapidly, will effectually seal the aperture. Attention is then paid to the peritoneum, and any stomach contents which have escaped are swabbed out with dry gauze ;

FIG. 383.—Ulcer of stomach invading the pancreas, with infarction of spleen. (St. Bartholomew's Hospital Museum.)

a drainage tube is inserted or not, according to the length of time which has elapsed between the perforation and the operation, and the surgeon's estimate of the amount of soiling of the peritoneum. Luckily the contents of the stomach are not very septic, most organisms having been killed by the gastric juices.

*Subsequent course.*—In the majority of cases, especially if treated soon after the perforation, all the symptoms subside and a permanent cure results. In any case a careful observation must be maintained, and if the symptoms do not abate, and if the pulse, temperature and leucocyte count remain high, suspicion of a subphrenic abscess must arise.

## Contractions following Ulceration of the Stomach.

In the process of healing of an ulcer there is always a certain amount of scar or fibrous tissue formed, which may be of inappreciable amount, but if the ulcer is large and of long standing, there is an excess of scarring and fibrosis; this may produce considerable contraction and give rise to various

deformities of the stomach, according to the position of the original ulcer. The contraction may vary from a slight puckering of the surface peritoneum to a firm ring which almost completely obliterates the lumen of the stomach and acts as a bar to the passage of food through that organ. Supposing the ulcer to have been situated in the region of the pylorus, a fibro-stenosis takes place causing obliteration of the pyloric aperture, but if situated in the body of the stomach the result is an hour-glass contraction.

**Fibro-stenosis of the pylorus.**—A fibro-stenosis resulting from an old gastric ulcer is naturally gradual in its onset, and for a time the musculature of the stomach is able, by extra exertion, to propel its contents through the narrowed opening; but with increasing constriction this gradually fails and the stomach becomes dilated. This dilatation may in time become so great that the stomach may descend as far as the pelvis and appear to fill the greater part of the abdomen. The prominent signs are those of long-standing dilatation of the stomach, viz., the passage of visible peristaltic waves across the stomach from left to right, the vomiting of large quantities of partly digested and fermented food, and progressive emaciation. The dilatation is ascertained by auscultation and percussion and by means of an X-ray examination after the taking of a bismuth meal. The vomiting has no direct connexion with the taking of food, and may occur only once in the twenty-four hours, or even at less frequent intervals, and when it occurs it is in very large quantities and comes as a great relief to the patient. The vomit contains all manner of sarcinæ, yeast cells and other organisms, due to the putrefaction of food, and in this respect is similar to the conditions found in gastric carcinoma; but the chemical analysis is different, for here the proportion of active hydrochloric acid to the mineral chlorides is not diminished, whereas in gastric carcinoma it is.

FIG. 384.—Bilocular stomach. (Westminster Hospital Museum.)

*Treatment.*—As a palliative measure the stomach may be washed out daily by means of a soft rubber tube and irrigated with warm water, so as to clear away putrefactive products. By this means the patient may be kept comfortable for a prolonged period, but it is no cure. The most successful treatment is a gastro-enterostomy, and as soon as the diagnosis has been established this should be done. The operation is eminently satisfactory, resulting in a permanent cure, and has entirely supplanted the earlier methods, such as pyloroplasty or Loretta's operation for stretching the pylorus. The posterior gastro-enterostomy should always be done where possible, though sometimes

if there are so many adhesions that it is not possible to turn the stomach up, the anterior operation is called for, a loop of jejunum being brought round in front of the great omentum and transverse colon and anastomosed to the anterior surface of the stomach.

**Hour-glass contraction of the stomach.**—If the ulcer is situated, not at the pylorus, but on the lesser curvature of the stomach near the centre of that organ, the constriction forms in the body of the stomach, though this is not so common as at the pylorus. In cases of ulcer of long standing the cicatricial contraction may be so great as to divide the stomach into two compartments and give rise to a condition known as hour-glass contraction, the proximal sac of which is generally the larger. The symptoms are very much the same as those of pyloric obstruction, and unless its presence is suspected the condition may easily be missed. The following manœuvre may lead to a correct diagnosis: if the stomach tube is passed and a known quantity of fluid run in and then syphoned off, a little less will be recovered than was put in; and moreover, after the stomach has been washed out with clear fluid a sudden rush of stomach contents may come, indicating the emptying of a second compartment.

Two operations are performed for this condition:—

1. A gastro-enterostomy, anastomosing the jejunum to the proximal compartment of the stomach; or

2. A gastro-gastrostomy, that is to say, the formation of a lateral anastomosis between the two compartments of the stomach.

If these two compartments are of about equal size the latter operation is preferred, provided that the opening between the two is made of a large size, that is to say, not less than 2 inches. If the proximal compartment is much the larger, as is generally the case, then a gastro-enterostomy is more satisfactory.

## Tumours of the Stomach.

Malignant disease is by far the commonest form of new growth of the stomach. It is of frequent occurrence, being stated to be the cause of death in 20 per cent. of all males and 13 per cent. of all females dying of malignant disease in this country. The commonest age for its appearance is between forty and sixty, though cases have been recorded much earlier.

*Pathology.*—The part of the stomach usually attacked is the pyloric end near the lesser curvature, which fact lends some weight to the view that a carcinoma of the stomach is, at any rate in some cases, to be ascribed to the irritation caused by an old gastric ulcer. The growth, which is usually a carcinoma of the columnar-celled type (rarely sarcoma), occurs in three main forms:—

1. The common form, in which there is ulceration and tumour formation about the neighbourhood of the pylorus, with a tendency to glandular infection and spread of the disease mainly along the lesser curvature. The glands along the greater curvature may also be infected, and the head of the pancreas with all the tissues at the back of the stomach may become infiltrated. As the disease advances the stomach becomes dilated with the narrowing of the pyloric canal, decomposition of food occurs, and the patient has the added trouble of being unable to assimilate food, and wastes at a more rapid rate than the mere presence of a carcinoma elsewhere would occasion. In the later stages, with involvement of peritoneal surfaces, there is ascites and blood-stained fluid in the peritoneum. Secondary growths may appear all over the surface of the abdomen and in the liver and other viscera.

2. A rarer form of cancer is that which infiltrates all the wall of the stomach, resulting in a thickened, puckered condition comparable to a leathern bottle. In this condition there is but little tendency to ulceration and the pylorus is not as a rule much narrowed, and therefore vomiting is not a prominent feature. Infiltration of the peritoneum occurs, and there may be considerable ascites in consequence.

3. A still rarer form of growth is a well-localised, sessile or pedunculated growth which is more often sarcomatous than carcinomatous.

*Diagnosis of gastric carcinoma.*—The most important signs of an advanced case are vomiting of large quantities of fermented material, dilatation of the stomach, the presence of a tumour in the upper part of the abdomen, and a history of rapid wasting. The vomiting is not directly connected with the taking of food, occurring perhaps only once or twice a day, or even at longer intervals, and affording temporary relief to the patient. The vomit often contains traces of altered and digested blood, giving to it the appearance of "coffee-grounds." As a result of the stasis, many sarcinæ, yeast cells, and other organisms flourish, and may be found in large quantities.

FIG. 385.—Carcinoma of the pylorus with dilatation of the stomach. (St. Bartholomew's Hospital Museum.)

Chemical analysis shows that the proportion of active hydrochloric acid to mineral chlorides is diminished, whereas in gastric ulcer it is increased.

Diagnosis has to be made from chronic dyspepsia, fibro-stenosis of the pylorus, and tumours of the gall-bladder, kidney and colon. An X-ray examination after a bismuth meal gives an indication of the amount of dilatation of the stomach and the length of time required for food to pass through the pylorus. Traces of blood may also be found in the stools (occult blood).

Such are the appearances of an advanced case, in which the difficulties of diagnosis are not great, but it may be taken as a rough rule that when a carcinoma is sufficiently advanced to be palpable as a tumour through the abdominal wall it is too late to attempt anything more than a palliative operation. It is therefore of the utmost importance to secure an early diagnosis in time to remove the growth, and this is difficult owing to the insidious onset of the disease. The first symptoms are loss of appetite and failing strength, associated with a certain amount of pain which is commonly attributed to dyspepsia; it is only after prolonged and ineffectual treatment

that the suspicion reaches the mind of the practitioner that he has something more serious to deal with. If a patient over forty years of age, previously in good health, begins to complain of dyspepsia, and if the condition does not yield quickly to medicinal and dietetic remedies, then a most careful examination should be made by all the available methods. Should abdominal examination reveal nothing, or should there be some tenderness over the region of the stomach, it may be deemed advisable to administer an anæsthetic to overcome muscular resistance. With improved knowledge of the gastroscope it may become possible to inspect the interior of the stomach so as to make sure of the presence or absence of a carcinoma, but at the present time, if there is any reasonable doubt, the right course is to open the abdomen and make the diagnosis by inspection. Even then it may not be possible to come to a correct decision without the aid of a histological examination, for an old

FIG. 386.—Carcinoma of pylorus. (St. Bartholomew's Hospital Museum.)

ulcer surrounded by a certain amount of fibrosis may simulate a carcinoma very closely.

**Treatment of malignant disease of the stomach.**—If after the abdomen has been opened the stomach is found to be the seat of a carcinoma, the question will then arise as to the correct treatment to be carried out. The wish of the surgeon must be to do a radical operation and remove the growth together with the affected glands. Mere extent of the carcinoma on the wall of the stomach does not necessarily form a bar to operation, for the major portion or whole of the stomach can be removed; but if extensive secondary growths are present in the peritoneum and viscera, or if the surrounding tissues, such as the pancreas and mesentery, are infiltrated, it is not worth while to attempt it, and the test to apply to such a case is whether the whole extent of the disease can be removed.

**Radical operation.**—A variety of operations have been devised for the removal of a portion of the stomach, and for these the student is referred to a text-book on operative surgery. One operation only, and that the one found

most generally useful, will be dealt with here, namely, a partial gastrectomy combined with a gastro-enterostomy. The portion of the stomach affected is gauged, the vessels on either curvature isolated, tied in two places and divided, and two pairs of clamps then placed on the stomach and duodenum wide of the growth and the affected portion severed. Both the cut ends are invaginated, sutured, and entirely closed by a continuous Lembert suture. A gastro-enterostomy is then done in the usual way on the remaining piece of stomach.

If the tumour happens to be one of the rare pedunculated variety, it may be possible to excise it locally together with the affected area of the stomach.

**Palliative operation.**—There is only one to be considered, namely, gastro-enterostomy, which is used when a radical operation is impossible and when there is sufficient space to perform the anastomosis on the proximal side of the growth. In cases of "leathern bottle" stomach, however, little good can be done by any operation, and, seeing that the pylorus is but rarely obstructed, even a gastro-enterostomy is of no value.

*Treatment by radium.*—For inoperable cases an attempt is made now and then to arrest the growth by the use of radium passed through the œsophagus into the stomach by means of a rubber tube. Scant success has attended this manœuvre.

## Acute Dilatation of the Stomach.

This is a very serious condition, due to other than mechanical causes, in which the stomach becomes rapidly and enormously distended with wind and fluid, and is rapidly fatal unless recognised and treated early. In many instances there is no evidence to show what is the origin of the condition, and in such cases, "idiopathic" as they are called, the surgeon is not called upon to interfere. Occasionally, however, the dilatation supervenes on surgical operations, especially when the region of the solar plexus has been handled or injured; and it has been known to follow operations on the kidney in which pressure has been exerted on the epigastric region in order to force the kidney up into the wound. The prominent signs are vomiting of large quantities of fluid, great thirst, restlessness, rapid pulse, and a great diminution of the quantity of urine secreted, amounting sometimes to complete suppression. The stomach is enormously dilated, and if a tube is passed a large quantity of flatus and fluid is drawn off; the patient is temporarily relieved, but the stomach begins to fill again almost at once, and in a few hours four or five pints may have accumulated again. The cause of this condition is not known with accuracy, but it looks as if there is some paralysis of the stomach associated with septic absorption.

The *treatment* consists in repeated lavage of the stomach with warm water and the use of such stimulants as brandy and strychnine. Gastrostomy has been performed, but has not proved of great service. It has been suggested (Moynihan) that the correct operation, if any, is gastro-enterostomy, so as to provide for a continuous drainage from the stomach into the intestines.

## Congenital Stenosis of the Pylorus in Infants.

This condition is met with chiefly in male infants, and is recognised by intractable and forcible vomiting, visible peristalsis of the stomach, constipation, and a palpable lump in the region of the pylorus. The stenosis is due to spasm of the pylorus, which is followed by hypertrophy of the circular muscular coat, and narrowing of the pyloric aperture. In

consequence of the difficulty of the passage of food the infant wastes rapidly, and in bad cases assumes a wizened, mummified appearance.

*Treatment.*—By careful selection of the food and systematic lavage of the stomach with warm saline night and morning before decomposition of food sets in, the pyloric spasm may subside and the hypertrophied muscle become normal. If the condition does not yield to these gentler methods, an operation becomes unavoidable. The most suitable operation is that described by Rammstedt. The abdomen having been opened in the middle line, the pylorus is lifted out of the wound, and all the coats of the pyloric canal, down to, but not including, the mucous membrane, divided in the long axis of the pyloric canal; no attempt is made to suture the widely gaping cut. Speed is an important factor. The results and low mortality of this operation are most encouraging.

FIG. 387.—Congenital stenosis of pylorus. (St. Bartholomew's Hospital Museum.)

### Duodenal Ulcer.

The origin of an ulcer in this situation must be put down to causes identical with those which produce a gastric ulcer, and the symptoms arising are much the same, though there are a few signs which tend to indicate the seat of the mischief. The ulcer is usually single and situated close to the pylorus, or at any rate proximal to the bile papilla. It occurs most frequently in men about the age of forty, in contradistinction to gastric ulcer, which is most common in young girls.

*Clinical features.* — The patient usually complains of a good deal of pain after food, associated with epigastric tenderness, acidity and flatulence. A special characteristic is the so-called "hunger-pain," which comes on about two hours after a meal—that is to say, at the time when the acid gastric juice is passing into the duodenum. The pain is often relieved by taking more food, for then the pylorus closes, and the gastric juice mixed with the food is for the time retained in the stomach, whilst alkaline and pancreatic secretions are stimulated (Mayo Robson and Moynihan). Vomiting and hæmatemesis are not so common as in gastric ulcer, but the latter sign, when it occurs, is of grave import. The methods of diagnosis are the same as for gastric ulcer.

*Differential diagnosis* has to be made from carcinoma of the pylorus, and gall-bladder and appendix disease, and it may be that the diagnosis can

really only be made after the abdomen has been opened and the viscera examined.

As in the case of gastric ulcer, hæmatemesis and melæna, cicatricial contraction and perforation form complications of duodenal ulcer, and the treatment is the same in each case. It must, however, be remembered that it is difficult to suture a perforated duodenal ulcer by inversion without unduly narrowing the lumen of the intestine, and it is therefore advisable to perform a gastro-enterostomy as well.

# Section XXIII.

## SURGERY OF THE LIVER, BILE PASSAGES, PANCREAS, AND SPLEEN.

### Surgery of the Liver.

### Injuries of the Liver.

Injuries to the liver are generally due to direct violence, such as stabs or gunshot wounds, or to crushing injuries when the hepatic region is pressed between two blunt substances. The latter are often associated with severe lesions of one or more of the adjacent viscera. When the liver is considerably enlarged, as in some malarial affections, or is the site of a large cyst, a comparatively slight force may give rise to a severe rupture. The injury may be associated with an external wound or be entirely subcutaneous.

The right lobe of the liver is usually affected, and the superior and anterior convex aspects more frequently than the inferior or concave. The damage to the liver may be either a laceration in which the capsule is torn, a subcapsular rupture, or a small internal hæmorrhage. All injuries to the liver are associated with extensive hæmorrhage. This is much greater when the capsule is torn than when the injury is limited to the hepatic substance. In the former case blood, or blood and bile, are poured out into the general peritoneal cavity in considerable quantity.

Damage to the stomach, intestine, especially duodenum, kidneys, or spleen, is quite commonly a serious complication of hepatic injuries.

*Symptoms and signs.*—All injuries to the liver are accompanied by symptoms and signs of shock, rigidity of the abdominal wall in the upper and right quadrant, tenderness on pressure in the affected region, and usually limitation of the respiratory movements. In the severe cases there is usually marked rigidity of the abdominal walls, and respiratory movements are almost *nil*. When shock is extreme and marked pallor is present, the conditions suggest severe intraperitoneal hæmorrhage, and evidence of free fluid in the abdominal cavity and shifting liver dulness can often be obtained. If the patient remains untreated and still survives, abdominal distension quickly becomes apparent, and jaundice also may develop.

*Diagnosis.*—When a patient has sustained a stab, a gunshot, or other deep penetrating wound in the right hypochondriac or epigastric regions, and this wound leads inwards towards the liver, an injury to the liver can be diagnosed with certainty. In other cases in which there is no external wound, but in which the injury has been caused by some form of crush or blunt violence, rupture of the liver must be suspected when there are signs of extreme shock or intraperitoneal hæmorrhage.

*Treatment.*—Penetrating stab and gunshot wounds in the hepatic region should be submitted to immediate operation. The patient should be anæsthetised and the track and direction of the deep portion of the wound investigated by probing. Usually it will be found desirable to enlarge or excise the external wound in order to determine the extent of the damage. If hæmorrhage is severe, plugging with long strips of gauze will usually, for

the time being, arrest the hæmorrhage. When the extent of the injury to the liver has been ascertained in the case of stabs, the wound should be treated by careful deep-suturing with catgut. In gunshot wounds, packing with a long strip of gauze will generally be found effective. Sometimes when the injury to the liver is severe a rubber drainage tube may be passed down to the bottom of the wound and the parts outside packed with strips of gauze.

In non-penetrating wounds the symptoms are generally not sufficient to enable the surgeon to decide the site, extent, and nature of the injury. In these cases the abdomen should be explored either in the middle line or in the right linea semilunaris. After the peritoneal cavity has been opened, the clot should be sponged out, and the position and extent of the hepatic injuries determined. If hæmorrhage is still going on, it can be temporarily controlled by applying digital pressure to the hepatic artery and portal vein. This is most easily effected by placing the forefinger in the foramen of Winslow and the thumb upon the anterior aspect of the gastro-hepatic omentum. The margins of the rupture in the liver should be approximated and fixed in close apposition by insertion of deep sutures of thick catgut. If torn branches of the hepatic artery or portal vein can be seen on the ruptured surfaces, they should be picked up and ligatured. When the rent in the liver substance is so extensive as not to permit of successful suturing, the space should be packed with long strips of gauze. Occasionally both suturing and packing may be combined.

*Prognosis.*—Severe injuries to the liver which have required surgical operation have in the past been accompanied by a considerable mortality. Success in these cases, however, can be achieved if they are treated immediately after the occurrence of the injury. The published mortalities have been from 30 to 70 per cent.

*Complications.*—The most common complication is sepsis due to contamination at the time of the original injury. This condition is treated in the manner recommended later.

## Abscess of the Liver.

An abscess of the liver is a collection of pus in its substance and within the fibrous or Glisson's capsule. The abscess may be single or multiple. Single abscesses most frequently occur in the right lobe.

*Causes.*—There are two distinct varieties of single or localised abscess of the liver—(*a*) an abscess occurring in a patient who has had dysentery and due to the transference of the *amœba coli* from an area of dysenteric ulceration in the large intestine to the liver, and (*b*) an abscess due to infection of hepatic tissue by micro-organisms of suppuration in association with an injury of the liver, with a hydatid cyst, or by direct extension from an infected gall-bladder or bile-duct. The abscess caused by the *amœba coli* occurs in persons who have lived in India, Egypt, or other tropical country where amœbic dysentery occurs, and is generally called a "tropical abscess."

Often an abscess of this kind develops some time after the period of infection with dysentery, and in some patients the symptoms of dysentery may have been so slight as not to have been noticed. The period which elapses between infection with dysentery and the onset of an abscess of the liver varies considerably, and may be not uncommonly one or more years.

Multiple abscesses usually involve both lobes, the right more extensively than the left, and are due to a pyæmic infection of the liver by septic organisms which are carried to it by the portal vein from a septic focus within the portal

area, such as occurs in suppurative appendicitis, septic thrombosis of internal hæmorrhoids, enteric fever, etc.

The micro-organisms which have been found in multiple abscesses are streptococcus, staphylococcus, *bacillus coli*, typhoid bacillus, etc.

Another form of multiple abscess which is more chronic than those already mentioned is that due to actinomycosis. This is occasionally met with in this country and usually follows an actinomycotic affection of the cæcum and vermiform appendix.

*Symptoms and signs.*—The cardinal symptoms of hepatic abscess when single and localised, whether due to the *amœba coli* or dependent upon pyogenic infection, are enlargement of the affected portion of the liver, raised and irregular temperature with occasional rigors and night sweats, pain and tenderness in the hepatic region, pain in the region of the right shoulder or at the inferior angle of the right scapula, and signs of septic poisoning. As already stated, the right lobe is more frequently involved, and when the abscess is located in the lower or anterior portion it can be felt as a swelling extending below the costal margin and moving synchronously with respiration; if the anterior or lateral aspect of the organ is chiefly affected, the overlying intercostal space or spaces may be obliterated, bulging, and œdematous. When the upper portion of the liver or diaphragmatic aspect is the seat of the purulent collection, there is usually perihepatitis also, and a cough, worse at night and convulsive in character. On percussion the liver dulness is found to be increased upwards, and with the stethoscope a fibrinous rub may be detected. Examination on a fluorescent screen or an X-ray photograph of the hepatic region may give important indications as to the position and extent of a deeply-seated abscess. Pain only becomes apparent or a marked symptom after the inflammation and abscess formation has extended to the surface of the organ and caused a localised peritonitis. Often rigidity of the abdominal muscles in the right hypochondrium and adjacent portion of the epigastrium will be found, especially when the abscess is approaching the surface. When left untreated, abscesses of the liver, especially those of amœbic origin, may go on for a considerable period. Ultimately they extend either towards the skin or burst into some adjacent organ or structure, such as the lung, pleura or bronchus, the stomach or duodenum, colon or pelvis of the kidney. Thus the contents may be coughed up, vomited, passed *per anum*, or discharged through an external opening. A few cases have been recorded in which an abscess of the liver has burst into the pericardium and caused sudden dissolution.

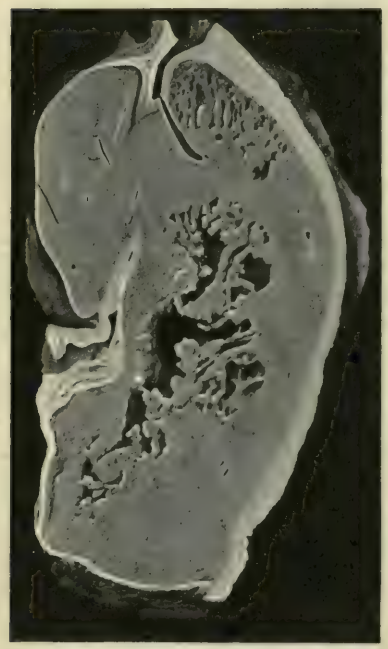


FIG. 388.—Abscess of liver following dysentery in India. 159 ounces of [pus removed by aspirator on two occasions. A right thoracic empyema supervened and caused death. (Westminster Hospital Museum.)

The pus of an hepatic abscess, when amœbic in origin, is generally of a brownish or chocolate colour, and has the consistency and appearance of anchovy sauce; this is caused by the presence of broken-down hepatic tissue *débris*, and blood. When secondary infection has occurred streaks or patches of grey or yellow material can be seen mixed with the brown. Difficulty is often experienced in detecting the *amœba coli*, but if a scraping be taken from the wall of the abscess, especially after it has been opened for a few days, and immediately fixed and examined, its presence can be demonstrated. The contents of a pyæmic abscess vary in appearance, according to the variety of micro-organism present.

In pyæmic abscess of the liver the symptoms may be masked or overshadowed by those due to the primary affection. Usually, however, they develop whilst those of the primary disease—appendicitis, enteric fever, etc.—are still apparent, although in occasional cases their onset may be delayed. They are—pain, either in the hepatic region or in the right shoulder, tenderness and enlargement of the liver (both lobes often being affected), raised temperature, rigors and sweats, marked leucocytosis, and signs of toxæmia. Jaundice is not infrequent and is due to spread of inflammation along the intrahepatic bile-ducts.

*Diagnosis.*—When making a diagnosis it must be remembered that some forms of basal pneumonia, subphrenic abscess, and empyema of the gall-bladder extending to the adjacent portion of the liver cause symptoms similar to those of an abscess of the liver. Careful consideration, however, of the previous history, the occurrence of dysentery, and the mode of onset of the symptoms will usually enable these affections to be eliminated. In doubtful cases the value of a skiagram, especially in determining the upper hepatic border, should be remembered. Malaria may be mistaken for hepatic abscess, but in this affection there is nearly always enlargement of the spleen, whilst the administration of quinine and examination of the blood will give diagnostic information.

*Treatment.*—In cases of tropical abscess which are not complicated by a secondary infection it is usually sufficient to aspirate the contents and to treat the patient with a course of emetin, gr. i. being given subcutaneously on each of twelve succeeding days. The drug may be administered by the mouth in the form of bismuth emetin iodide, gr. i., in keratin-coated capsules, or as pulv. ipecacuanhæ, grs. x., but neither is so effective as emetin given hypodermically. Whenever an abscess of the liver contains pyogenic organisms, it should without delay be treated by surgical measures, the abscess cavity laid open, the contents evacuated and drainage established.

The methods of surgical approach to an abscess of the liver are—(*a*) *abdominal incision*, anterior or lateral, according to the position of the abscess; (*b*) *thoracic incision* through the overlying portion of the chest wall, usually with removal of portions of one or more ribs and opening of the pleura; (*c*) *combined abdominal and thoracic incision* when the abscess is very large and underlies portions of the abdominal and thoracic walls (in these cases the pleura as a rule is peeled upwards and not opened); (*d*) *lumbar incision*—immediately below and parallel with the last rib—when the lower and posterior portions of the right lobe of the liver are the seat of the abscess. When the surface of the liver overlying the abscess has been exposed by one of the above routes, the surrounding structures are protected from possible contamination by packing with gauze, and then the hepatic substance is incised with the scalpel, and the purulent contents allowed to escape. In cases of difficulty in locating the abscess after exposure of the liver an exploring needle

may be passed in until pus is found. This is left in position and an incision made along it. After evacuation the opening is temporarily plugged with gauze, the protective packing removed, and the margins of the incision in the liver fixed to those of the opening in the parietes by careful suturing. The plug is then removed and drainage established. Irrigation of the cavity is not usually to be recommended, but for this purpose a solution of emetin hydrochloride or quinine bihydrochloride in water has been used. When the abscess has been approached through the anterior abdominal wall, much assistance may be gained by placing the patient in a prone or semi-prone position in order to facilitate drainage.

Multiple pyæmic abscesses consequent upon infection from the portal area are usually associated with septic pylephlebitis, and do not offer many prospects of success to surgical measures. The primary affection should be determined and surgically treated if possible, and the affected portion of the liver may be incised and drained by one of the methods already described.

*Prognosis.*—Localised abscesses of the liver, especially those of dysenteric origin, when treated by appropriate surgical measures, offer very good prospects of recovery. The most favourable ones are those situated in the anterior or lateral portions of the right lobe. Multiple pyæmic abscesses usually terminate fatally, although occasionally they have recovered.

## Hydatid Cysts.

This form of cyst is met with more frequently in the liver than in any other part of the body. It is caused by the ova of the *tænia echinococcus* which gain admission to the stomach of the patient. Here the gastric juice dissolves the outer coating of the ovum and sets free a small embryo which adheres to the mucous membrane. This develops and works its way through the mucous membrane until it gains entrance into one of the radicals of the portal vein. Thence it is conveyed to the liver, becomes arrested in one of the hepatic capillaries, and there develops into a hydatid cyst. The tumour or cyst is usually located in the right lobe. It may be single, or several may be present. The cyst wall consists of two layers, an external, whitish in colour and of the nature of a firm membrane, and an inner cellular layer, from which scolices develop. In addition, each cyst is surrounded by a firm fibrous capsule which is derived from the hepatic tissues, and consists chiefly of fibrous tissue and blood-vessels. A hydatid cyst of the liver may be either *proliferating*, in which numerous secondary cysts are derived from the internal lining membrane, or *non-proliferating* (sterile), in which there are no daughter cysts, whilst the interior is filled with a clear, non-albuminous, opalescent fluid of low specific gravity—1,003 to 1,012. In the case of proliferating cysts hooklets may readily be found in the fluid.

Hydatid cysts are not common in England. They occur in patients who have lived in Australia or other countries where the disease is common, or in men who have lived in close association with dogs, such as shepherds, or are employed in slaughter-houses where diseased animals are killed. Occasionally the ova of the parasite are introduced by the consumption of watercress or other uncooked vegetable which has been contaminated by the excreta of a dog in whose intestine the *tænia echinococcus* lives as a parasite.

*Symptoms and signs.*—The disease is much more frequent in men than in women. Hydatid cysts of the liver or subphrenic space generally give rise to slowly growing swellings, which become manifest either by the formation of a painless tumour in the hepatic region, by the development of pressure

symptoms due to involvement of adjacent viscera, by rupture of the cyst into the peritoneum, the pleura, the pericardium, the lung, the alimentary canal or urinary system, or by the infection of the cyst with septic micro-organisms and the formation of a hepatic abscess. Occasionally a hydatid cyst of the liver has burst into one of the hepatic ducts, and the daughter cysts have passed downwards towards the duodenum and at the termination of the common bile-duct completely blocked the opening so as to cause biliary obstruction and jaundice. Entrance of bile into a hydatid cyst at once kills the parasite. Hydatid fremitus or thrill may occasionally be obtained, but is not constant.

If a cyst ruptures into the peritoneum, the patient at once develops an urticarial rash owing to absorption of toxins.

*Diagnosis.* — Hydatid cysts of the liver may exist for a considerable period before giving rise to symptoms, and unless one or other of the complications just mentioned occurs, they may not be discovered until the patient dies from some other disease and a *post-mortem* examination is made. When an abdominal swelling is suspected of being a hydatid cyst, it may be punctured with the needle of an exploring syringe in order to confirm the diagnosis. This should, however, only be done in cases where the surgeon is prepared to proceed at once with a curative operation provided the exploration is positive. If this is not done, material may escape from the interior of the parasitic cyst along the line of puncture and infect the peritoneal cavity.

FIG. 389.—Hydatid cyst in the liver. (St. Bartholomew's Hospital Museum.)

*Treatment.*—The only effective treatment for a hydatid cyst of the liver is surgical operation. The details depend on the situation and size of the cyst and its relation to surrounding or adjacent viscera. The first step is exposure of the portion of liver containing the parasite. This is effected by making an incision over the affected area, either through the abdominal or thoracic walls, or both, or in the lumbar region immediately below and parallel with the last rib. When the affected portion of the liver

has been exposed, the surrounding viscera are protected with gauze packing and the overlying portion of hepatic substance and cyst wall incised. The cavity of the cyst being laid open, the contents—fluid and daughter cysts—are evacuated. Next the internal lining is seized with forceps, stripped away and removed. The further treatment varies according to the size of the cyst. When small and near the surface of the liver it is occasionally possible to dissect out the entire cyst wall and obliterate the space from which it has been removed by deep sutures, whilst in cases of moderate size the wall of the deep portion of the cyst can often be similarly approximated and then the margins of the incision in the liver sutured and the external wound closed. If, however, the cyst is large, or not in an accessible position, the margins of the opening in the cyst and the wound in the liver should be fixed to the parietes and drained by a rubber tube. The remaining portion of the external wound is then closed.

When a hydatid cyst has suppurated it is treated in the manner already described in connexion with "abscess" (p. 941). Occasionally plaques of calcification in the cyst walls may be met with. They should be removed by scraping with a large spoon. Hydatid cysts of the liver if treated surgically generally do well, but when suppuration has occurred the treatment is very prolonged, and amyloid disease may occur as a complication.

### Ptosis of the Liver and other Viscera—Glénard's Disease.

In this condition the liver is displaced downwards in the abdomen; combined with this is an elongation of the right lobe towards the iliac fossa, forming the floating, appendicular or linguiform lobe of Reidel. Glénard described the liver as being held in position mainly by the vena cava and intra-abdominal tension, so that the heavier right lobe sinks forwards. The anterior edge is in addition thinned out and prolonged from the lobe, being very often partly constricted by a fibrous band formed from a thickening of the visceral peritoneum. Glénard's disease is most frequent in women, owing to general abdominal relaxation, such as occurs after repeated pregnancies. Glénard also found evidence of associated liver and biliary disease in many of his cases, especially in the few male patients. The disease has been attributed to tight lacing, but this is probably not the cause, since the transverse bands on the liver supposed to indicate such pressure appear to be of congenital origin. The symptoms are dragging sensations, indigestion and attacks of colic, and jaundice from kinking of the bile-duct. The diagnosis must be made from floating kidney and gall-bladder distension.

*Treatment.*—A well-fitting Curtis belt, with regulation of the bowels, diet and exercises.

### New Growths.

(A) *Innocent.*—**Angiomata** in the form of large cavernous nævi are sometimes found in the livers of elderly patients. They may be large enough to form palpable swellings in the right hypochondrium and have occasionally been excised successfully.

**Adenomata** also occur, but are of pathological interest only.

(B) *Malignant.*—Primary malignant disease of the liver is exceedingly rare, but large, nodular, **carcinomatous or sarcomatous masses** secondary to disease of some portion of the abdominal alimentary tract, the breast, bones, and elsewhere are very common.

## Diseases of the Portal Vein.

There are several regions in which communications exist between the portal and the systemic venous systems. Dilatation of the venules in these situations may occur as the result of obstruction to the portal vein or the inferior vena cava.

These anastomoses occur between the superior and inferior hæmorrhoidal veins, important in cases of hæmorrhoids; between the veins of the ascending and descending colon and the posterior abdominal wall; between the left branch of the portal vein and the veins of the anterior abdominal wall *viâ* the par-umbilical vein; between the veins of the bare area of the liver and the under surface of the diaphragm; and between the coronary and œsophageal veins.

**Pylethrombosis,** or simple obstruction of the portal vein, occurs particularly in cirrhosis of the liver, also in syphilis and from tumours and peritoneal inflammation. Obstruction of the portal vein itself is indicated by ascites, of the splenic vein by hæmatemesis, and of the superior mesenteric vein by pain, vomiting and collapse.

**Septic pylephlebitis** is the result of infection derived from some portion of the gastro-intestinal tract. It is caused especially by suppuration in the neighbourhood of the cæcum and appendix, but it does not occur in cases of extensive ulceration following dysentery and typhoid fever. It gives rise to severe rigors and profuse sweating with marked enlargement of the liver, in which multiple abscesses are formed. Jaundice only occurs late in the disease when over two-thirds of the liver substance have perished, unless an abscess pointing in the transverse fissure cause pressure on the hepatic duct. This is in marked contrast to suppurative cholangitis, in which jaundice is profound and one of the earliest symptoms. The disease is nearly always fatal, but success has occasionally followed cholecystostomy.

## Paracentesis Abdominis.

*Paracentesis abdominis*, or tapping the abdomen for ascites, should be done in the linea alba midway between the umbilicus and the pubic symphysis. The bladder having been emptied, a small incision should be made through the skin, and the trocar and cannula, with a tube attached to convey the fluid into a vessel, should be thrust into the abdomen. If the patient is fat the abdominal wall may be as much as three inches or more in thickness. The fluid should flow off quite slowly, and a many-tailed bandage, previously passed round the body, be gradually tightened as the fluid flows in order to keep up pressure on the abdominal vessels, and so prevent syncope. The fluid is occasionally drawn off with a Southey's trocar-cannula, and as the abdomen takes many hours to empty on account of the small size of the cannula, there is no fear of syncope. When paracentesis is repeated, the omentum adhering to the abdominal parietes may be wounded, and there is then fresh blood mixed with the serous fluid. Hæmorrhage may occur from a wound of the deep epigastric artery if the puncture is made laterally.

## Artificial Venous Anastomosis.

Cases of ascites are often tapped a great number of times; one patient had 250 gallons of fluid removed in 150 tappings. After repeated tappings patients have spontaneously improved, whilst the fluid has ceased to accumulate. Coincident with this improvement the superficial veins of

the wall of the abdomen and chest have become enlarged, the condition from its appearance being fancifully named "caput Medusæ." The blood in such enlarged veins can be seen to flow upwards.

To produce this anastomosis artificially, Talma and Rutherford Morison introduced the operation of fixing the omentum between the deeper layers of the abdominal wall through an epigastric incision. The inner surface of the parietes, and the anterior and upper surfaces of the liver, may also be scrubbed with a sponge to favour the formation of adhesions. The superficial veins gradually enlarge, and the patient is relieved from the frequent accumulation of fluid. The prognosis varies with the cause of the ascites, some cases being permanently relieved. The operation should not be employed as a last resource, as confidence in it will be weakened by the high mortality which is then attributed to it. *Post-mortem* examinations show that a very free anastomosis between the portal and parietal vessels is established, large vessels being found in the adhesions.

## Surgery of the Gall-bladder and Biliary Passages.

### Injuries of the Gall-bladder and Bile-ducts.

On account of the comparatively small size of the gall-bladder and the deep situation of the hepatic ducts these injuries are far less frequently met with than those of the liver. Most of the cases are due to stabs or gunshot wounds, but rarely rupture of the gall-bladder or bile-duct has been caused by a crushing injury. On one occasion the gall-bladder was found lying free in the abdominal cavity after a severe crush (author's case). If there is an external wound, bile or bile mixed with blood may exude in moderate quantity. When a perforation of the gall-bladder or bile-duct is suspected, the external wound should be at once enlarged, the peritoneal cavity opened, and the region of the gall-bladder and bile-duct examined. If the gall-bladder is the seat of the injury and is either perforated or lacerated, it should be excised at once. If, however, the common bile-duct is injured, the wound in it should be sewn up with fine chromicised catgut; if completely severed, and it is not possible to perform an anastomosis between the two ends, each extremity should be closed by a circular ligature and the fundus of the gall-bladder anastomosed with the duodenum.

### Cholecystitis.

The essential cause of all surgical affections of the gall-bladder and bile-ducts apart from neoplasms is an infection by pathogenic micro-organisms. These organisms are either *bacillus coli communis* or *bacillus typhosus*, in rare cases staphylococcus or streptococcus. The route of infection of the gall-bladder and biliary ducts has been a source of discussion for a long period. Most authorities incline to the view that micro-organisms gain an entrance into the biliary system by the opening of the common bile-duct into the duodenum; some, that the portal vein is the route of infection, organisms being taken up from the alimentary canal, conveyed into the radicals of the portal vein and thence to the liver. Others, again, think that organisms are conveyed by the general blood-stream along the hepatic and cystic arteries. In all cases, whatever the route, the contents and mucous membrane lining

A Dilated Gall-bladder, removed by Operation.

The cavity is occupied by facetted calculi ; the walls are much thickened by chronic inflammation, and the mucous membrane is acutely inflamed. (St. Bartholomew's Hospital Museum.)

the gall-bladder become infected. Once infection has occurred, changes take place in the mucous membrane, and gall-stones are one of the most frequent results. Localised masses of micro-organisms, inspissated mucus or cholesterin crystals form the nuclei of most gall-stones. As regards their chemical composition, gall-stones in the main consist of cholesterin, calcium bilirubinate and carbonate. In some cases, pure cholesterin stones are met with; in others, almost pure pigment stones—calcium bilirubinate and biliverdinate—but the great majority are a mixture of these three constituents. The conditions which may require surgical interference as the result of bacterial infection of the biliary system or the formation of gall-stones are :—

1. *Acute ulcerative, phlegmonous or gangrenous cholecystitis.*
2. *Empyema of the gall-bladder.*
3. *Mucocele of the gall-bladder.*
4. *The presence of gall-stones in the gall-bladder or biliary ducts.*
5. *Biliary fistulæ.*
6. *Acute intestinal obstruction owing to impaction of a gall-stone in the alimentary canal* (see p. 967).
7. *Chronic cholecystitis with or without gall-stones.*

1. **Acute ulcerative, phlegmonous, or gangrenous cholecystitis.**—Acute cholecystitis is due to a virulent infection, generally by a bacillus of the coliform group, and may be complicated by the blocking of the cystic duct by an impacted gall-stone and thrombosis of the cystic artery. The mucous lining of the gall-bladder and cystic duct becomes considerably swollen and œdematous, whilst the other coats of the gall-bladder are often the site of small abscesses. In places the mucous membrane may slough and form ulcers, and patches of gangrene may develop in the adjacent portions of the wall of the gall-bladder. Occasionally perforation may occur and give rise to all the signs of acute septic peritonitis. The walls of the gall-bladder are usually purple in colour and very thick and soft, whilst the contents are pus, sloughs and blood-stained serum.

*Symptoms and signs.*—Acute cholecystitis usually begins with an attack of pain, variable in intensity, in the right hypochondrium, and often referred to the right scapular or shoulder regions. Occasionally the initial pain is in the epigastric and not in the right hypochondriac region; or it may be referred to the right iliac fossa, thus simulating appendicitis. After the pain, nausea and vomiting appear. The temperature is raised, but irregular, and often a temperature of 103° or thereabouts is noted. There is limitation of respiratory movements on the right side, with marked muscular rigidity and tenderness in the right hypochondriac region. The gall-bladder may be felt to be considerably enlarged and tender, and may be actually visible as a pyriform swelling extending downwards towards the umbilicus. Jaundice is not present, if the common bile-duct is not involved. At first the nausea and vomiting are persistent, but often, after twenty-four or forty-eight hours, they become less. Examination of the blood shows a marked polymorphonuclear leucocytosis.

*Diagnosis.*—Acute cholecystitis is to be diagnosed from acute appendicitis, perforation of a duodenal or gastric ulcer, biliary or renal colic, and right basal pneumonia. The presence of muscular rigidity in the upper quadrant of the right side of the abdomen, together with the presence of an enlarged gall-bladder, high temperature, nausea, and vomiting, are usually sufficient to make an exact diagnosis. Acute pancreatitis may have to be distinguished from this affection; in this, however, the constitutional symptoms are much more severe and the pain is more in the epigastric and lumbar regions.

*Treatment.*—When the diagnosis is fairly clear and the symptoms are severe, surgical intervention is indicated without delay. The gall-bladder and biliary ducts should be exposed by an ample incision through the upper part of the right rectus muscle. If the diagnosis is confirmed, the cystic and common bile-ducts should be investigated by palpation for the presence of gall-stones. The procedure to be adopted depends upon the severity of the inflammatory condition and the state of infiltration of the walls of the cystic duct. In most cases it is safer to incise the gall-bladder, evacuate the contents, and fix the margin of the incision in the gall-bladder to the deep portion of the parietal wound. If the mucous membrane lining the gall-bladder can be readily detached, this may be done. When, however, the cause of the condition is impaction of a gall-stone in the cystic duct, and the portion of the duct between the site of impaction and the common bile-duct is fairly healthy, or when the gall-bladder is actually gangrenous, then the gall-bladder should be removed, the detachment of the organ commencing at the cystic duct. After removal, the space should be packed with a large plug of gauze and the remaining portion of the external wound closed.

*Prognosis.*—A good result may be anticipated if the treatment suggested above is carried out at an early stage, but when the gall-bladder has already been perforated and the adjacent part of the peritoneal cavity contaminated, then the prognosis is not so good. In some cases it may be advisable at a later stage—that is to say, some weeks or even months later—to remove the remnants of the gall-bladder by a second operation.

2. **Empyema of the gall-bladder.**—This condition consists of a collection of pus within the gall-bladder, the lumen of the cystic duct having been obliterated. The virulence of the infective micro-organisms which give rise to this condition is not so marked as in acute gangrenous cholecystitis. A pyriform swelling develops in the right hypochondriac region. It is attached to the liver, somewhat tender on palpation, and moves freely on respiration. The patient usually has an irregular temperature.

The treatment is removal of the gall-bladder without previously opening it.

3. **Mucocele of the gall-bladder.**—Mucocele of the gall-bladder is characterised by the collection within the gall-bladder of a large quantity of clear mucoid fluid which is secreted by the mucous glands which line its interior. It is always associated with blocking or obliteration of the cystic duct, usually by impaction of a small gall-stone in its lumen. After impaction no bile can pass into the gall-bladder from the liver. The mucous membrane continues to secrete considerable quantities of mucus, and the small amount of bile pigment present at the time of impaction is quickly absorbed.

Beyond slight pain referred to the right hypochondrium and the presence of a gradually increasing tumour, pyriform in shape and not tender on palpation, there are no signs or symptoms of importance. The swelling can be felt to be attached to the under surface of the liver, and moves freely on respiration. Skiagrams may demonstrate the size of the swelling and the impacted gall-stone. The treatment is similar to that of empyema of the gall-bladder—that is to say, cholecystectomy.

4. **Presence of gall-stones in the gall-bladder or bile-ducts.**—Gall-stones may be present in the gall-bladder for a considerable period and give rise to no symptoms. When, however, the gall-bladder becomes the site of inflammation or a gall-stone passes into the cystic or common bile-duct, signs and symptoms become apparent. Gall-stones may become impacted in any portion of the biliary passages, but the commonest situations are the neck of the gall-bladder or beginning of the cystic duct, the termination of the latter

where it enters the common bile-duct at an acute angle, the common bile-duct itself either where it lies in front of the foramen of Winslow or the dilated portion (ampulla of Vater), which is embedded in the duodenal wall, and finally, more rarely, in some portion of the hepatic ducts.

*Symptoms and signs.*—An attack of pain is the most frequent symptom met with in gall-stones, and is of great importance in establishing a diagnosis. The pain may be local or referred. When local, it will be either "biliary" colic or "dyspeptic." Dyspeptic symptoms are usually referred by the patient to the epigastric or adjacent hypochondriac regions, and are said to be of the nature of a dull gnawing, boring pain or "cramp of the stomach." The onset of the pain is a point of some importance; it most frequently comes on at night, when the patient is in bed. Hunger pain is not uncommon. There is tenderness on pressure over the gall-bladder, and an abdominal swelling may be detected, but this is not constant. Biliary colic in most cases occurs sooner or later. This pain appears to be due to muscular contraction of the gall-bladder or biliary ducts, and is of the nature of a disordered and irregular peristaltic action of the diseased viscus or canal. It usually comes on quite suddenly, and, except for previous slight dyspeptic symptoms, there may be nothing to indicate its nature. The patient experiences sudden pain in the upper part of his abdomen, which becomes rigid; he feels faint, becomes collapsed, is nauseated and frequently vomits. Sometimes he will writhe on the floor in the most severe agony. The patient sweats, and the temperature may rise to 103° or even more. If the obstruction continues the pain may improve but still remains severe. It is now more definitely referred to the right hypochondrium, back, or shoulder. If a calculus passes along the duct into the duodenum or falls back into the lumen of the gall-bladder, the pain suddenly disappears. Tender areas may be elicited either immediately below the ninth costal cartilage or at a point one inch above the umbilicus along the line drawn from it to the right ninth costal cartilage. Palpation in the right hypochondrium, with elevation of the liver from behind, may elicit a tender area in the region of the gall-bladder. In a large number of cases of gall-stone or cholecystitis there is no evident enlargement of the gall-bladder, although it may be distended either with calculi or the products of inflammation. The presence of a tender, deep-seated area or induration in the right hypochondrium is of greater importance in diagnosis than the presence of a definite tumour. When a tumour is present and there is no associated jaundice, the cause is obliteration of the cystic duct by gall-stones. A swelling of the gall-bladder associated with jaundice in the great majority of cases indicates a carcinoma of the head of the pancreas. During an attack of biliary colic, vomiting is usually present and intermittent. The vomited material consists of the contents of the stomach and, later, bile; blood is not usually present. With gall-stones in the gall-bladder, especially when the patient is thin, crepitations may be detected owing to the calculi rubbing one against the other This sign, however, is not readily elicited. In most cases there is fever, due to infective processes, and when the infection subsides, the temperature falls to normal. Whilst the infection is limited to the gall-bladder, there is usually no serious rise in temperature, owing to the fact that the gall-bladder has a very sparse lymphatic system. When, however, the infection extends to the bile-ducts or to the adjacent peritoneum, then marked elevations of temperature occur. X-ray investigation of patients suffering from gall-stones has, to a very limited, but increasing, extent, enabled the surgeon to determine their exact position before operation Gall-stones in the gall-bladder or cystic duct

are not usually associated with jaundice. When jaundice is present it indicates obstruction in the hepatic or the common bile-duct, usually in the latter. When a calculus is impacted in the common bile-duct it is usually demonstrated by intermittent attacks of colic, recurrent jaundice, and intermittent fever.

Jaundice due to stone is to be diagnosed from that due to carcinoma of the head of the pancreas or a sclerosing pancreatitis. The onset of jaundice in the former is usually sudden and heralded by an attack of colic—the colour varying in intensity from time to time and often completely disap-

FIG. 390.—X-ray photograph of a gall-stone, showing the characteristic ringed appearance. (Finzi.)

pearing. In diseases of the head of the pancreas, jaundice is slower, more gradual in onset, and steadily progressive. There may be a rise of temperature in both conditions, but it tends to be higher in gall-stones than in carcinoma.

In carcinoma of the head of the pancreas the gall-bladder is found to be distended and may be felt as a considerable abdominal tumour extending down to or below the level of the umbilicus. On the other hand, the gall-bladder is usually small, thickened, and sometimes almost buried in the liver in cases of obstruction to the common bile-duct by gall-stones.

Stercobilin, although much diminished in amount, can always be found in the stools of patients suffering from calculous obstruction; it is never

completely absent, as it may be in the later stages of carcinoma of the head of the pancreas.

A gall-stone impacted in the distal end of the cystic duct will produce a mucocele and at the same time may, by pressure from without upon the common bile-duct, cause obstructive jaundice of the type characteristic of malignant disease of the pancreas.

*Treatment.*—In most cases of gall-stones surgical treatment is indicated. It rarely happens that a gall-stone, once formed, remains single and is passed *viâ* the biliary ducts into the intestinal canal. The surgical measures for the removal of gall-stones and the treatment of associated inflammatory conditions should be recommended at once whenever the presence of stones either in the gall-bladder or in one of the bile-ducts has been diagnosed. A stone is a constant source of danger to the health and life of a patient on account of the liability to serious inflammatory infections and attacks of biliary colic, and also because of the possibility of the development of carcinoma of the gall-bladder or bile-ducts. When it has been decided to operate it is very often a matter of doubt as to the extent of the disease and the position of the calculus or calculi. Therefore it is strongly advised that the incision in the abdominal parietes should be so placed that the entire biliary system—gall-bladder, cystic duct, hepatic ducts, and common bile-duct—can, if occasion demands, be explored and dealt with through the same opening. For this purpose a vertical incision commencing at the right costal margin in the region of the eighth costal cartilage and extending downwards through the junction of the middle and outer thirds of the rectus abdominis muscle is recommended. If the incision above mentioned does not suffice it may be extended upwards or downwards according to the needs of the case which is being operated upon. When in the former direction this should be effected by prolonging it in an upward and inward direction towards the ensiform cartilage and along the outer boundary of the subcostal triangle. Considerable assistance can be obtained in effecting a thorough exposure of the hepatic and common bile-ducts by elevating the lumbar and lower dorsal portions of the spinal column. This manœuvre separates the lower margin of the thorax and the pelvis, rotates the liver on a transverse axis, and brings the bile-ducts nearer the wound in the anterior abdominal wall. When the abdominal cavity has been opened the gall-bladder and ducts should be carefully palpated in order to determine the character of any retained calculi and the position of adhesions. If the gall-bladder is very distended it may be necessary to defer the investigation of the common bile-duct until the former has been emptied. The operations which are found to be of the greatest value in the treatment of cholelithiasis and its complications are :—

(*a*) **Cholecystostomy.**—In this operation the fundus of the gall-bladder is incised, the contents—gall-stones, pus, mucus, bile, *débris* and so on—evacuated, and then the margins of the aperture fixed by catgut sutures to those of the upper portion of the parietal incision. These fixation sutures should be passed through the entire thickness of the wall of the gall-bladder and then through the serous and deep aponeurotic layer of the abdominal wall. A tube is inserted and free drainage established, thus forming a biliary fistula, which, if there is no obstruction in the common bile-duct, will close in from three to six weeks. The indications for cholecystostomy are :—

1. A single stone, or a few gall-stones, in the gall-bladder, the walls of which are not thickened, inflamed or ulcerated.

2. Cases of slight or moderate infective cholecystitis.

3. Cases of very acute infective cholecystitis, in which there is considerable inflammation and œdema of the wall of the gall-bladder and the surrounding tissues.

4. Any gall-bladder in which, on account of the general conditions, it is not safe to perform an operation of excision.

(*b*) **Cholecystectomy.**—Removal of the entire gall-bladder and proximal portion of the cystic duct. The gall-bladder is detached from the under surface of the liver by working from the fundus towards the cystic duct or in the reverse direction commencing just proximal to where that duct joins the hepatic duct. In the latter case the cystic duct is seized with two pairs of pressure forceps, divided between, and the separation then continued towards the fundus. If the liver can be lifted up and rotated on its transverse axis so as to give a good exposure of the gastro-hepatic omentum, the latter method will be found easier to carry out. The cystic blood-vessels in this case are ligatured at the beginning of the operation, and consequently little hæmorrhage, merely slight oozing from the surface of the liver from which the gall-bladder has been separated, is met with. The indications for cholecystectomy are :—

1. Empyema of the gall-bladder.
2. Gangrenous cholecystitis
3. Mucocele of the gall-bladder.
4. Chronically inflamed and sclerosed gall-bladder.
5. Contracted and functionless gall-bladder.
6. Early carcinoma of the gall-bladder.

(*c*) **Choledochotomy.**—Incision of the common bile-duct either in the gastro-hepatic omentum or behind the first portion of the duodenum. The duct should first be exposed by dividing the anterior layer of the gastro-hepatic omentum, and, if necessary, in addition to this lifting up and retracting downwards the first part of the duodenum. An incision should be made parallel to the long axis of the duct and on the proximal side of the obstruction, sufficiently long to enable the surgeon readily to extract the impacted calculus. Incision of the common duct as it lies in the gastro-hepatic omentum is applicable in most cases. When the calculus is impacted in the lower part of the common bile-duct and cannot be moved, the incision should be made in that portion of the common duct which lies behind the first part of the duodenum. After extraction of the calculus or calculi the opening in the duct should be closed with catgut sutures and the gastro-hepatic omentum sutured in front. In cases of severe infection with ulceration it is wiser not to suture the duct but to establish free drainage. This latter operation is sometimes known as *Choledochostomy*.

(*d*) **Choledocho-lithotomy—trans-duodenal.**—When a calculus is impacted in the lowest portion of the common bile-duct immediately above where it opens into the second part of the duodenum, the duodenum may be incised and the calculus removed by slitting up the duct.

## Carcinoma of the Gall-bladder.

Malignant disease of the gall-bladder is usually columnar-celled or, in very rare cases, spheroidal-celled carcinoma, but a few cases are on record in which the neoplasm has had the histological structure of squamous-celled carcinoma. A more detailed histological investigation of the latter has, however, suggested that they are really endotheliomata. Sarcoma of the gall-bladder has been met with clinically, but is nearly always secondary to a primary growth elsewhere. Most cases of carcinoma of the gall-bladder are associated

with the presence of gall-stones, although occasionally no calculus has been found. The affection is more common in women than in men, and is usually met with in the later decades of life.

The neoplasm is most frequently located in that portion of the fundus of the gall-bladder which lies in close contact with the inferior aspect of the liver or in the region of the commencement of the cystic duct. The disease appears to be of comparatively slow growth, and in the early stages forms a hypertrophic mass projecting into the lumen of the gall-bladder. At a later period, however, it directly invades the liver or becomes attached to the hepatic flexure of the colon.

*Symptoms and physical signs.*—In the early stages these are those of gall-stones in the gall-bladder, followed by the development of a hard, nodular, not very tender mass which is fixed to the liver. Jaundice is not usually present, except in the latter stages, when the common hepatic duct or the ducts in the hilum of the liver have been involved.

*Diagnosis.*—It is not usually possible to diagnose this affection from gall-stones in the gall-bladder. On abdominal exploration, the nodular, hard gall-bladder will suggest the nature of the disease.

*Treatment.*—In the early stages, when there are no secondary growths in the liver and no infiltration of the adjacent omentum or large intestine, cholecystectomy should be performed. The lymph gland lying on the cystic duct and those in the gastro-hepatic omentum should also be removed. In addition to removing the gall-bladder, it may be necessary in the more advanced stages to remove a wedge-shaped portion of the liver. The margins of the incision in the liver are brought together by the insertion of a series of interrupted sutures of chromicised catgut introduced by a fully-curved blunt-pointed needle. The prognosis is fairly good in those cases in which the disease is entirely limited to the gall-bladder in the region of the fundus.

## Carcinoma of the Bile-ducts.

Carcinoma of the bile-ducts is most frequently met with at the junction of the common bile-duct with the duodenum or in the cystic duct shortly before it joins the common hepatic duct. Malignant disease is rare in other parts. In the lower portion of the common bile-duct it is usually a columnar-celled carcinoma; elsewhere it may be either a columnar- or, more rarely, a spheroidal-celled carcinoma. The disease progresses steadily, causing obliteration of the lumen of the affected part of the duct and development of progressive jaundice. The bile-ducts on the proximal side of the disease usually become dilated and distended with bile, but the gall-bladder, when the cystic duct is the site of the primary disease, becomes distended with mucus, or mucus and blood. Gall-stones may or may not be met with in connexion with this affection.

*Clinical aspect.*—There are no physical signs beyond gradual enlargement of the liver owing to distension of the smaller biliary ducts, and of the gall-bladder when the lower portion of the common bile-duct is involved. Jaundice is a marked symptom, and gradually progresses. An exact diagnosis cannot usually be made apart from an abdominal exploration, and in many instances the disease has been confused with carcinoma of the head of the pancreas. If an operation is performed in the early stages and the growth located in the lower portion of the common bile-duct, it can occasionally be successfully excised. Subsequently an anastomosis may be established between the proximal portion of the bile-duct and the duodenum, or the divided duct may be closed and a cholecyst-duodenostomy performed. In cases involving the cystic duct, cholecystectomy is indicated.

## Surgery of the Pancreas.

### Pancreatitis.

(A) **Acute pancreatitis.**—Acute pancreatitis may be either catarrhal, hæmorrhagic, suppurative, or gangrenous. As a general rule, patients suffering from catarrhal pancreatitis do not require surgical treatment, but the catarrhal condition may become hæmorrhagic or gangrenous.

(i.) **Hæmorrhagic pancreatitis.**—This disease is the most common acute affection of the pancreas requiring surgical treatment. It has been produced experimentally by injecting material into the pancreatic duct or into the substance of the gland. Bacteriological investigation of cases which are operated upon at an early stage often shows the presence of streptococcus pyogenes; in some, however, no pathogenic micro-organisms are discovered. In a certain number the disease apparently follows the bacteriological infection of the ducts of the pancreas consequent upon impaction of a gall-stone in the lowest portion of the common bile-duct. The *bacillus coli communis* has been thought to cause the disease in this way, but apparently does so only in exceptional cases.

The organism may gain access to the pancreas from the duodenum by way of the ducts; from the gall-bladder by way of the common bile-duct, ampulla of Vater, and duct of Wirsung, or possibly by the lymphatics surrounding the common bile-duct (Deaver and Ashurst); from the portal vein by way of the liver and bile-ducts, or from the general circulation.

The disease has occasionally followed typhoid fever, influenza and mumps. Injury does not usually cause acute pancreatitis, although a few cases are on record.

The pancreas becomes acutely inflamed, swollen and œdematous. Patches of necrosis appear and hæmorrhages occur into the necrotic areas. Blood activates the pancreatic juice, liberating trypsin, which assists in the destruction of the gland. With infective necrosis aided by auto-digestion, larger vessels are involved and profuse hæmorrhage occurs behind the peritoneum or into the lesser or greater sac. Raised white patches of *fat necrosis* appear on the peritoneum, most constantly on the transverse meso-colon. It is generally assumed that these are due to the direct action of pancreatic juice, but they have also been found in the pleura and pericardium.

The affection is much more frequent in men than women, and statistics which have been collected show the proportion to be thirty males to about fifteen females. It is a disease of one of the middle decades of life, the majority of cases occurring between thirty and fifty-five. The patients usually are obese, and may give a distinct history of alcoholism or previous attacks of gall-stone colic and jaundice.

*Symptoms and signs.*—An attack of hæmorrhagic pancreatitis usually occurs quite suddenly, and in many instances the patient gives no history of any apparent cause. The attack is usually characterised by both abdominal and general constitutional symptoms. Abdominal pain referred to the epigastrium is a common form of onset. This may be so acute that the patient may fall down in the street from the severity of the attack. It may cause faintness or even collapse, and resembles in many respects that of gall-stone colic. The pain in pancreatitis, however, usually remains at first in the epigastric region, and later is referred to one or both lumbar regions. Vomiting generally occurs in an early stage, coming on soon after the onset of the abdominal pain. It is not usually very severe, in some cases there being only

ACUTE HÆMORRHAGIC PANCREATITIS.

The pancreas, dissected to show its main duct and the common bile-duct, is viewed from its posterior aspect. Three gall-stones are seen in the common bile-duct, just at its termination in the duodenum. (Unfortunately, much of the blood-stained appearance of the pancreas was lost during the preservation of the specimen.)

nausea and retching. Immediately after the onset of the attack the pulse is rapid and weak. Occasionally, however, it is not affected. In the later stages it invariably becomes more rapid and bounding. The temperature, at first, may be subnormal, and rarely reaches 101°. When, however, the patient is recovering from collapse, and irritative lesions of the peritoneum become established, it may rise to 103° or even more.

In the early stages of the disease the patient's face and extremities are distinctly cyanosed, and, in addition, there may be some dyspnœa or difficulty in breathing. The cause of the cyanosis is not clear; probably it is part of a general toxæmia. In many cases there is a distinct icteric tinge of the skin and conjunctiva, but marked jaundice does not usually develop. When present, this jaundice may be due either to obstruction of the common bile-duct by a gall-stone or to pressure upon the bile-duct by the diseased and enlarged pancreas.

There is some slight diminution in the abdominal movements on respiration, but muscular rigidity of the abdominal walls is not usually met with. A definite swelling may be detected in the epigastrium in the normal position of the pancreas, but this swelling is usually diffuse and has the normal resonance of the stomach in front of it. Occasionally it may project below the liver and above the lesser curvature of the stomach when the patient is the subject of gastroptosis. Percussion may assist in the localisation of a tender swelling in the sub-hepatic region. When felt, the swelling will be found to be fixed and not to move with the movements of respiration.

*Loewe's adrenalin midriasis test.*—Adrenalin has no action upon the pupil of the healthy individual. In certain pathological conditions it causes dilatation of the pupil, an effect which has been claimed to be pathognomonic of pancreatic insufficiency. The size of the patient's pupils and their power of reaction to light are noted. Two drops of 1 in 1,000 adrenalin solution are instilled into one conjunctival sac, and after an interval of five minutes this is repeated, the other eye being used as a control. If, at the end of half an hour, dilatation of the pupil has occurred, the test is positive.

Normal urine contains from 10 to 20 units of *diastase*, an amylolytic ferment. In cases of pancreatic insufficiency the diastase content of the urine frequently rises to 100 or 200 units or more. *Glycosuria*, sometimes intermittent, may also be present. An increased diastase content in the urine, a positive Loewe's reaction, and glycosuria constitute Mackenzie Wallis's "Tripod of Tests" for pancreatic disease.

*Course of disease.*—If untreated, after the severe and sudden onset, attacks of violent pain in the epigastrium usually continue with occasional vomiting. Marked rigidity of the abdominal walls does not soon become apparent. When, however, the affection has spread to the adjacent tissues and the lesser sac of the peritoneum, then signs and symptoms of acute peritonitis appear. The general condition of the patient becomes quickly worse, and sometimes in two or three days death supervenes. Usually, however, the disease runs a longer course.

*Differential diagnosis.*—The affections from which acute hæmorrhagic pancreatitis is to be distinguished are:—

1. Acute appendicitis.
2. Biliary colic.
3. Perforation of a gastric or duodenal ulcer.
4. Acute intestinal obstruction such as is produced by volvulus, strangulation by a band, or an internal hernia.

*Treatment.*—When acute hæmorrhagic pancreatitis is diagnosed or suspected,

the sooner an operation can be carried out for the relief of this condition the better are the prospects of the patient's recovery. The abdomen should be opened a little to the right of the middle line, the incision extending from the epigastrium to below the umbilicus. If the diagnosis is correct, blood-stained serous fluid will be found in the general peritoneal cavity or in the lesser sac of the peritoneum or in both, and white patches of fat necrosis will be seen in the great omentum. The pancreas is best exposed by dividing the anterior two layers of the gastro-colic omentum immediately below the greater curvature of the stomach. When the lesser sac of the peritoneum has been opened in this way and the stomach lifted upwards, the enlarged hæmorrhagic pancreas can be seen. It should be freely incised in its long axis so as to evacuate as much of the blood and serum as possible. After this has been done and all free fluid and blood-clot removed from the lesser sac and the field of operation, one or more rubber drainage tubes of large calibre should be passed down to the site of the incisions in the pancreas. The pancreas adjacent to the tubes and the lesser sac are now packed with a large strip of gauze, and the margins of the opening in the gastro-colic omentum are fixed by a few points of suture to the cut margins of the parietal peritoneum of the original incision. The portion of the parietal wound not occupied by the drainage tubes and packing is then closed with buried catgut sutures. When the stomach is prolapsed and the engorged and enlarged pancreas projects above the lesser curvature of the stomach, the gastro-hepatic omentum may be incised and the further treatment carried out as above. The gauze packing should be left in for thirty-six or forty-eight hours, and the drainage tube for some considerable time, since it usually happens that large pieces of the pancreas necrose and are discharged. The general after-treatment of these cases is similar to that of any other acute abdominal disease.

(ii.) **Suppuration with abscess formation and gangrene of the pancreas.**—Abscess or gangrene of the pancreas usually follows the acute hæmorrhagic condition already described. It is very rare to find a primary suppuration, and, when it occurs, it generally involves the head or adjacent portion of the body—rarely the tail. It is characterised by the development of a tender swelling in the epigastrium in which deep pitting or fluctuation may be detected. It is associated with a set of clinical symptoms similar to those already described in acute hæmorrhagic pancreatitis, but not so sudden and acute in onset. The *treatment* is similar to that of hæmorrhagic pancreatitis.

(B) **Chronic pancreatitis.**—Chronic pancreatitis is an inflammation of the gland due to infection by pathogenic micro-organisms. This infection may extend directly along the ducts of the pancreas from the common bile-duct, or from the duodenum, or other adjacent organ, which has been the site of previous inflammation or ulceration.

Chronic pancreatitis may be *catarrhal*, in which the cellular elements of the gland are primarily involved, or *interstitial*, in which the connective tissue lying between the lobules and acini is mainly affected. This interstitial condition may be a sequel of a primary catarrhal inflammation of the membrane lining the ducts and acini.

*Symptoms and signs.*—The symptoms resemble in many respects those of cholelithiasis with arrest of a gall-stone in the common bile-duct. Jaundice, slight in degree, is very often present. In the severer forms the head and body of the pancreas become the site of a hard, somewhat tender, swelling which may be mistaken for carcinoma of this organ. The temperature is usually slightly raised, but there is nothing characteristic. The other signs

of chronic pancreatitis are pain, located mainly in the epigastric region, occasionally in the lumbar region, periodical attacks of nausea, vomiting and eructations, and progressive loss of weight. The character of the pain varies from that of a dull ache to colic. The attacks of pain and vomiting apparently have no definite relation to the taking of food. The loss of weight is usually progressive and in some cases very marked, and the appetite is considerably impaired. Patients suffering from chronic pancreatitis are usually constipated, but occasionally there may be diarrhœa. The stools are bulky, light-coloured, offensive in odour, and have a curious greasy and pultaceous appearance.

Of recent years much importance has been attributed to the so-called Cammidge pancreatic reaction, which depends upon the presence or absence of certain crystals in the urine. The composition of these crystals has not been definitely found out, although they are thought to be a pentose. This reaction is not of any great practical value in the determination of chronic pancreatitis, and more important information may be obtained from Mackenzie Wallis's " Tripod of Tests " already described (p. 955).

*Diagnosis.*—Often the exact diagnosis of chronic pancreatitis is difficult, but when patients complain of chronic and intermittent pain in the epigastrium, periodical attacks of nausea and vomiting, a slightly raised irregular temperature, the presence of a somewhat tender, indefinite swelling in the pancreatic region, slight jaundice, and the typical stools already described, then the diagnosis is fairly certain, especially if there is also an increased amount of diastase in the urine.

*Treatment.*—The slight cases, in which the diagnosis is not clear, are best treated in the early stages by medical measures, such as a cure at Harrogate or some similar spa. When, however, the diagnosis is fairly certain, surgical treatment should be adopted. This consists in exposure of the pancreas through an incision as for exposure of the gall-bladder and bile-ducts, but at a slightly lower level. The object of the operation is first to remove any cause such as a gall-stone in the common bile-duct, then to establish drainage of the biliary system. This is best carried out by drainage of the gall-bladder.

## Pancreatic Lithiasis or Calculus in the Duct of the Pancreas.

Pancreatic calculi are rare. They may be single or multiple. They consist of calcium carbonate. They may exist, apparently, for a long period without giving rise to any definite physical signs or symptoms and often have only been discovered on *post-mortem* examination, the patient having died from some other disease. The symptoms observed in the recorded cases resemble in many respects those of sub-acute pancreatitis—abdominal pain, nausea and vomiting, glycosuria, digestive disturbances and changed stools. A certain proportion of patients are jaundiced owing to obstruction in the lower portion of the common bile-duct. Flatulence, signs of digestive disturbance and loss of weight are due to the associated pancreatitis more than to the presence of a calculus itself. A definite diagnosis of pancreatic calculus can only be made when an X-ray photograph shows a shadow in the region of the pancreatic duct in a patient who has symptoms of chronic pancreatitis.

*Treatment.*—As the condition is generally accompanied by chronic pancreatitis, abdominal exploration is indicated. The position of a calculus having already been determined by an X-ray photograph, the abdominal incision is planned so as to facilitate its ready exposure. The anterior layers

of the gastro-colic omentum are incised, the stomach retracted upwards and the anterior aspect of the pancreas exposed. When the indurated area in the region of the calculus is detected, an incision is made in the long axis of the gland and the calculus exposed and removed. The incision in the pancreas can be sutured with chromicised catgut, but when there is evidence of considerable pancreatitis it should be left open and the field of operation drained with a rubber tube and packed with gauze.

## Cysts of the Pancreas.

Single or multiple cysts of the pancreas usually develop in the tail or in that portion of the body of the gland adjacent to the spleen. The contents of the cyst consist of changed pancreatic secretion, blood and cholesterin, and in the case of hydatid cysts, hydatid fluid, daughter cysts and hooklets.

*Pseudo-cysts* in connexion with the pancreas occasionally arise after a crushing abdominal injury, and within a few days or weeks form a large tumour in the upper part of the abdomen. As the result of a small tear in the gland, blood and pancreatic secretion are poured out, and together with some inflammatory effusion may become localised by plastic peritonitis as a distension of the lesser sac or a retro-peritoneal cystic swelling.

*Symptoms and signs.*—A cyst of the pancreas gives rise to a smooth, rounded, and fixed elastic swelling in the region of the affected portion of the gland. It does not move on respiration. This swelling generally increases slowly in size and projects forwards towards the anterior abdominal wall, first pushing forward the stomach and then forming a prominence either above or below it. Usually the stomach is pushed upwards towards the liver, the tumour projecting forwards below the greater curvature and between it and the transverse colon. Less commonly the stomach is pushed downwards and towards the left, in which case the cyst projects above the lesser curvature, having in front of it the gastro-hepatic omentum ; in rarer instances the cyst makes its way downwards behind the transverse colon and appears as a prominence below it. The symptoms caused by a cyst of the pancreas are usually slight, and are due to pressure upon either the stomach, the branches of the cœliac plexus, the common bile-duct, or the large intestine. Pain is a common symptom, dull in character and referred to the lower part of the epigastrium and the left lumbar region. Jaundice is only present when the common bile-duct is pressed upon. Pressure on the large intestine may cause constipation and, rarely, definite intestinal obstruction. When the cyst extends towards the right or involves the head of the pancreas, the portal vein and inferior vena cava may be pressed upon, and ascites or œdema of the lower extremities produced. Very rarely pressure on the adjacent ureter has caused hydro-nephrosis. When the cyst is associated with chronic pancreatitis, symptoms of this affection may be apparent. Often the only factor which draws the patient's attention to the presence of a pancreatic cyst is the apparent and gradual growth of an abdominal tumour.

*Treatment.*—When the cyst is comparatively small and arises in connexion with the tail or adjacent portion of the body of the pancreas, its removal may be possible. Usually, owing to adhesions between the cyst and the surrounding parts, this procedure is not advisable. It is better to expose the cyst through an incision in the overlying portion of the abdominal wall, evacuate its contents, fix the margins of the incision in the cyst to the cut edges of the posterior sheath of the rectus and parietal peritoneum, and drain.

Measures must be taken to avoid irritation of the skin by the escaping

pancreatic fluid, and this is best effected by the application of vaseline or other mineral oil. Pancreatic cysts treated by incision, evacuation and drainage usually do well, but a sinus, from which exudes irritating pancreatic fluid, may persist for a long time.

## Tumours of the Pancreas.

Primary carcinoma and sarcoma occur in the pancreas. Carcinoma is far the more common; it is an affection of middle or late life, practically all the cases occurring in people over forty years of age. The disease is more frequent in men than women. The head of the pancreas is the most common site for the neoplasm, but the body or tail may be affected. The tumour is usually of the spheroidal-celled type, and is scirrhous in character. Occasionally, however, the cellular type of neoplasm is met with, and the tumour has the appearance of an encephaloid growth. Secondary growths in carcinoma of the pancreas usually involve the liver at an early stage; the lymph glands round the superior mesenteric artery and cœliac axis are also affected.

*Symptoms and signs.*—The symptoms of carcinoma of the pancreas are gradual emaciation, steadily progressive jaundice with enlargement of the gall-bladder, and in some cases the appearance of an indefinite, deep-seated swelling in the epigastrium at the site of the head of the pancreas. Pain is not usually a marked symptom in the early stages. In carcinoma of the head of the pancreas the common bile-duct is at first compressed, invaded, and eventually occluded by direct extension of the growth. This causes the jaundice which is so marked a symptom of the affection. When the body or tail of the pancreas is the primary site of the disease, jaundice is not usual except in the very late stages. The gall-bladder may become so distended as to be apparent as a pyriform swelling extending below the umbilicus; the liver itself also is considerably enlarged. Patients suffering from carcinoma of the pancreas steadily lose weight and strength. The digestive disturbances are first those consequent upon interference with pancreatic secretion, and later those due to obstruction of the pylorus or duodenum. The fæces present the usual appearances of pancreatic diseases already described. Glycosuria may be met with, but often never develops. Carcinoma of the pancreas is rapidly progressive and usually terminates fatally within a year from the onset of the disease, often at the end of five or six months.

*Treatment.*—Surgery does not offer much hope of permanent success in cases where jaundice has developed. Two methods of operation are open to the surgeon, one in early cases—excision of the growth and adjacent portion of the pancreas,—and the other, cholecyst-enterostomy. If the disease is localised to the tail or the left portion of the body, an attempt should be made to excise it, the gland being cut through some distance from the diseased area. Cholecyst-duodenostomy is to be recommended as the operation of choice when there is no evidence of secondary growths in the liver and excision of the primary growth is impossible. By this means the jaundice and its accompanying irritative train of symptoms are relieved. Most cases of malignant disease of the pancreas, if untreated, die within a few months. When cholecyst-enterostomy is performed life may be prolonged for a year or even more.

## Surgery of the Spleen.

The normal spleen is situated in the left hypochondrium and is entirely concealed by the ribs. In disease it enlarges downwards towards the umbilicus, and, in exceptional cases, its lower border may even rest in the right iliac fossa. The anterior surface is always closely approximated to the anterior abdominal wall, so that neither stomach nor intestine can get in front of it, and thus, on percussion, it is uniformly dull from its lower extremity up to and beyond the costal margin. The anterior border presents the characteristic notch or notches, enlargement of which is proportionate to that of the rest of the organ, and can always be easily felt.

**Ruptured spleen.**—This is usually the result of a crushing accident and is frequently associated with fracture of the ribs and injury to the left kidney, stomach or intestines. In patients with chronically enlarged malarial spleens a comparatively light blow may prove fatal from rupture of the gland. The condition is generally accompanied by extreme shock, with signs of irritation of the peritoneum and of internal hæmorrhage. Abdominal respiration is much restricted or absent, the muscles on the left side are rigid, and there is tenderness on pressure. There is increasing dulness in the left flank, due to the collection of blood. Occasionally there is an almost complete absence of shock, and the symptoms of hæmorrhage may be masked for some hours. The abdominal cavity must be opened immediately and the pedicle of the spleen secured. If the tear in the splenic tissue is small, it may be closed by sutures of catgut, but in most cases it is necessary to remove the organ.

**Floating spleen.**—This usually occurs in thin women, and is part of a general visceroptosis. The spleen can be recognised by its position, shape and the notch in its anterior margin. The pedicle is liable to become twisted, causing strangulation of the blood supply and gangrene, necessitating operation. The general abdominal condition is treated by the adjustment of a well-fitting belt, but in some cases it may be justifiable to operate and fix the spleen extraperitoneally in its normal position (splenopexy). This is done by incising the parietal peritoneum and fixing its edges to the spleen.

**Abscess of the spleen** is rare except as part of a general pyæmia. It may follow typhoid fever or be due to the secondary infection of a hydatid cyst. The symptoms are those of a tender swelling of the spleen combined with the general effects due to toxic absorption. The abscess may rupture into the peritoneal cavity, the stomach or the pleura, or point on the abdominal wall.

The spleen should be removed, if possible, and, failing this, the abscess drained.

**Some causes of chronic enlargement of the spleen amenable to surgical treatment.**—1. *Cysts of the spleen.*—Hydatid cysts and simple serous cysts occasionally occur in the spleen, but are not common.

2. *Splenic anæmia.*—This is a disease that may occur at any age. It is characterised by a progressive anæmia associated with a much-enlarged spleen. Hæmatemesis is common, and may prove fatal. There is a red blood-count of 2,000,000 to 3,000,000 or less, with a hæmoglobin percentage of from 30 to 50. The white blood-count shows a leucopœnia which is directly proportional to the decrease in the number of the erythrocytes.

The disease may run a rapid course, ending fatally in a few months, or it may be prolonged for two or more years. In the early stages the disease can be cured by splenectomy.

3. *Banti's disease.*—This disease shows the symptoms and signs of splenic anæmia combined with those of hepatic cirrhosis. In the first stage of the

SARCOMA OF THE SPLEEN, REMOVED BY OPERATION.
(St. Bartholomew's Hospital Museum.)

disease, *i.e.*, before ascites has developed, splenectomy offers the best hope of cure.

4. *Acholuric jaundice.*—This is a condition which may be congenital or acquired, and is characterised by splenomegaly with persistent jaundice, but without the presence of bile salts in the urine. It is often a family disease, and may be associated with a marked primary anæmia. A sign of considerable diagnostic importance is the increased fragility of the red blood corpuscles in saline solutions, hæmolysis often beginning in solutions of a strength of 0·8 per cent., whereas normally it begins at a strength of 0·47. In some

FIG. 391.—Photograph of an enlarged spleen, weighing 2¾ lbs., removed from a girl, aged 8½, who was under Dr. de Havilland Hall, suffering from "splenic anæmia." Recovery and disappearance of the "anæmia" followed. A normal spleen from a girl of the same age was photographed alongside.

cases the patient suffers no inconvenience from his condition; in others, disabling attacks of abdominal pain and severe exacerbations of anæmia, with breathlessness and incapacity for work, occur. The disease is cured by splenectomy. As, in this condition, there is no perisplenitis with formation of adhesions, the operation is not attended by any appreciable risk of hæmorrhage.

**New growths of the spleen.**—Primary new growths of the spleen are very rare. Sarcoma may be recognised as a firm, nodular tumour in the situation of the spleen, and a diagnosis of malignancy is arrived at by the evidence of wasting and cachexia. Only in exceptional cases is removal practicable.

## Splenectomy.

The spleen is removed by an incision made parallel to, and 1 inch below, the left costal margin, starting at the outer border of the rectus and continuing downwards for about 5 inches. Great care must be exercised in separating any adhesions from the spleen, particularly those passing from the upper pole of the organ to the diaphragm, as in the latter is frequently situated a large communicating vessel between the coronary and splenic venous systems. In exceptional cases the density of the adhesions and the friability of the spleen make the risk of hæmorrhage so great that it is advisable to abandon the operation. When the spleen has been freed, it is gently delivered through the abdominal wound and the broad pedicle examined. Interlocking sutures of strong silk are used for securing the pedicle, care being taken not to include any part of the tail of the pancreas in the ligatures. Drainage for twenty-four hours through a stab-cut in the loin is advisable in all cases.

*The after-effects of removal of the spleen.*—Sepsis of the pedicle, spreading to the peritoneum and sometimes through the diaphragm to the pleura, occurs with undue frequency. It may be explained by the fact that the tail of the pancreas is often accidentally included in the ligatures of the pedicle, and this may also account for the irregular temperature which sometimes persists for several days. Pains in the long bones are sometimes described and attributed to the increased activity of the blood-forming elements of the marrow. In young patients removal of the spleen is succeeded by a hyperplasia of lymphatic tissue elsewhere, but this is only a transient phase. Severe hæmorrhage from the stomach or intestine may prove a fatal complication. There is an immediate rise in the number of the erythrocytes and a marked leucocytosis, but this effect soon passes off, and a moderate lymphocytosis supervenes and persists for one or two years.

# Section XXIV.

## SURGERY OF THE INTESTINES.

### Intestinal Obstruction.

Under this heading are grouped a number of conditions, exceedingly varied, which give rise to similar clinical features, the chief characteristics of which are obstruction to the passage of fæces and flatus, vomiting of bile and intestinal contents, abdominal pain and distension. The condition is a very serious one, for if the freedom of the bowels is interfered with the life of the patient is in danger. Obstruction may be due to—

1. **Mechanical causes,** such as narrowing of the lumen of the intestine by a growth, constriction by a band, or strangulation in a hernial aperture ;

2. **Conditions producing paralysis** of the muscular action of the bowel and consequent failure of its propulsive function, *e.g.*, embolism or thrombosis of the mesenteric vessels.

### Clinical Features of Intestinal Obstruction in General.

*Constipation and vomiting.*—The main feature is that there is a stoppage of the passage of fæces and flatus. This stoppage may be gradual or sudden, according as the obstruction is due to a gradual diminution of the size of the lumen of the bowel, such as may be caused by the growth of a carcinoma, or acute, in strangulation by a band, or incarceration in a hernial sac.

Let it be remembered first that after the occurrence of a complete occlusion of the intestine there may be one or more actions of the bowel, owing to emptying of the intestines below the seat of obstruction. The truth soon becomes obvious in a doubtful case, because after the lower bowel has been emptied by the use of one or more enemata nothing more comes away. The second great sign is vomiting, which sets in early and is persistent, the bowel, not being able to empty itself downwards, ejecting its contents upwards. The vomited material, which consists at first of the stomach contents, soon becomes bile-stained, later brownish in colour, and, having the odour of fæces, is termed "feculent." Owing to the greatly increased activity of the glands of the alimentary tract, the quantity vomited is far in excess of the amount taken into the stomach, and the action of vomiting is curiously pumping in character, not being associated with violent retching and nausea. It cannot be insisted upon too strongly that these are the two cardinal symptoms of obstruction which are invariably present, and, however obscured by other clinical appearances, are to be sought for and recognised.

If a patient has absolute constipation and vomiting, the condition should be regarded as one of intestinal obstruction and the cause sought for and relieved.

*Pain* is a variable factor ; it is usually acute at the onset, and may be referred to the seat of obstruction, as in hernia, or it may be general. It is often paroxysmal and griping in character, corresponding with a peristaltic effort

of the intestines to force their contents on : as the power of the muscular coat becomes exhausted owing to poisoning with toxins and the intestines become distended, the pain diminishes or may disappear.

*Distension* varies greatly, according to the position of the obstruction. If this is high up in the jejunum it may not be great, whereas if situated low down in the colon or rectum the abdomen becomes enormously distended and tympanitic. If the patient is watched for a few minutes, coils of distended intestines will be seen moving in peristaltic efforts,—the whole abdomen may look as if tied up in knots,—and with each peristaltic effort the face of the patient will indicate an increase of pain.

To palpation the abdomen is at first soft, the muscles becoming contracted only when peritonitis supervenes. A local tumour may sometimes be felt, and this, when present, offers an indication of what is the matter with the patient, but often little or nothing is to be made out of an abdominal examination as to the actual cause of the obstruction. The pulse-rate and occasionally the temperature, which at first are unaffected, become raised in the later stages. The facial aspect alters greatly and very quickly, the patient becoming anxious-looking and pale, with sunken eyes. The tongue becomes dry, brown and furred, and sordes form on the lips and teeth.

**Pathological effects of intestinal obstruction.**— Above the seat of obstruction the bowel becomes greatly distended and congested, and also, if the stricture is of long standing, hypertrophied, while the part below is collapsed and pale. In the distended portion of bowel there is an accumulation of intestinal contents and gases, as well as a fresh exudation of fluid, and in the later stages blood, from the intestinal membrane. The walls of the bowel become much congested, and petechial hæmorrhages may form in the peritoneal coat or under the mucous membrane, leading to softening, ulceration, and perforation. If the obstruction is due to strangulation by a band or incarceration in a hernial aperture, the blood supply is cut off, and the nutrition of the part supplied is therefore diminished, and gangrene is liable to occur. If the intestine is tightly nipped by a band, it may actually be cut right through. If the strangulation is not relieved, the termination is almost invariably fatal, usually from giving way of the bowel at some spot and subsequent septic peritonitis.

The length of time before a fatal termination is reached varies from a few days to about a week, according to whether the obstruction is acute or chronic, and whether it is situated high up or low down in the intestine. In general, it may be stated that the higher up the obstruction the more acute the symptoms.

**Examination of the patient.**—A careful history is to be taken, dealing with the length of time since the onset of symptoms, the condition of the bowels, and the presence of vomiting. The abdomen should be well exposed and its general appearance noted, especially as regards distension and peristalsis. By palpation it should be ascertained whether there is any obvious swelling or abnormal resistance. Supposing the symptoms present point to some form of intestinal obstruction, the next step is to examine all the hernial apertures for the presence of a hernia, not forgetting that in fat subjects a small strangulated femoral hernia may easily be overlooked. Failing any discovery of a hernia, a rectal examination should be made to ascertain the presence or absence of a carcinoma of the rectum or possibly an intussusception. In many cases, however, the cause of the obstruction cannot be found until the abdomen has been opened, and this, therefore, should not be delayed once the diagnosis of obstruction has been made.

**The Probable Causes of Obstruction at Different Periods of Life.**—

*In an infant.*—The cause of intestinal obstruction in a child only a few days old will usually be found to be a congenital occlusion of the rectum or malformation of the small intestine.

*In a young child.*—In this case intussusception is a common cause, and there also may be found strangulated inguinal hernia, strangulation by Meckel's diverticulum, or by bands following septic or tuberculous peritonitis, or by internal hernia.

*In an adult.*—Of the many varieties of obstruction perhaps strangulated hernia is the commonest; but also there may be strangulation by a band or internal hernia, pressure of tumours within or without the bowel, and volvulus of the small or large intestine.

*In old people.*—The commonest cause is carcinoma of the rectum or colon. Other causes are strangulated hernia or impacted fæces.

**Treatment.** The cause of the obstruction is to be found and relieved at the earliest possible moment, and if free exit for intestinal contents cannot be secured by the natural passages an artificial anus must be made. Choice of incision must vary with the diagnosis; thus, for a strangulated hernia it is made over the site of strangulation, or in the case of a carcinoma of the rectum it is made as for a left inguinal colostomy. If no diagnosis can be made before laparotomy, the abdomen should be opened, generally in the middle line below the umbilicus, and a sufficiently large opening made to ensure a complete exploration. As soon as the abdomen is opened, coils of distended intestine will as a rule protrude, and these must be handled with great care, for in their distended state they are very friable, and the peritoneal coat tears easily. The cause of the obstruction may be obvious at once; but more often it is not so, and then the exploration must be carried out in a systematic manner. The hand should be inserted into the abdomen, and the pelvic colon, cæcum, hepatic and splenic flexures examined for a tumour which is common in these situations. It should be noted, too, whether or not the large intestine is dilated, for this will give the surgeon the clue as to whether the seat of obstruction is above or below the ileo-cæcal junction. If no tumour is found, then the distended intestine should be turned over and a hunt made for a band. If this is not obvious, then a coil of collapsed intestine, when found, should be passed between the fingers until the site of obstruction is reached, which will be evident on account of the distended condition of the bowel on its proximal side. Sometimes, owing to great distension, this manœuvre is difficult to carry out, and it may become necessary to turn all the intestines into a towel wrung out in hot saline solution, when the cause cannot be missed. This method involves a certain amount of shock, and if the operation is being done in the late stages of obstruction it may be deemed inadvisable to submit the patient to the risk. Then the only thing left to do is to seize the lowest piece of distended bowel that can be found, bring it to the surface of the skin, and make an artificial anus. By this means the patient is relieved of the immediate obstruction, and in the event of survival a subsequent operation may be undertaken for the relief of the original obstruction and closure of the artificial anus. This course should be reserved for patients *in extremis* only, for the added dangers from shock, peritonitis, subsequent wasting, and the discomforts of an artificial anus are considerable. Even when the cause of obstruction has been found and relieved, the intestine above it may be so greatly distended with decomposed intestinal contents and paralysed by toxic products, that it may be unable to recover sufficient power to propel its contents. It may be deemed advisable, therefore, in such cases to incise the distended bowel, empty it of its contents, wash it out and afterwards

sew it up or leave an artificial anus. It is impossible to say exactly when this is necessary, and each individual case must be left to the judgment of the surgeon. It is only necessary to say here that these manipulations involve a risk of soiling the peritoneum.

Should the cause of the obstruction be a growth, then three courses are available :—

(*a*) The formation of an artificial anus on the proximal side ;

(*b*) In the case of an inoperable malignant growth, a short circuit by lateral anastomosis ; or

(*c*) The most radical, consisting of excision of the tumour combined with an intestinal anastomosis.

The condition of the patient and the fixity of the growth decide which of these courses shall be adopted, but, speaking generally, primary resection and anastomosis in cases of acute obstruction due to growth is an exceedingly dangerous procedure.

In gangrene of the intestine, due to pressure by a band or inclusion in an internal hernia, the gangrenous portion of bowel requires resection. If the condition of the patient will stand it, this should be followed by some form of intestinal anastomosis. The latter procedure adds perhaps another half an hour to the time of the operation, and it may be deemed inadvisable. If so, the two open ends of the bowel should be brought to the surface and secured, so as to leave an artificial anus, and afterwards, on recovery of the patient, a second operation is undertaken to restore the continuity of the intestine.

The treatment of special forms of intestinal obstruction will be dealt with under their separate headings.

## Varieties of Intestinal Obstruction due to Mechanical Causes.

1. Congenital malformations of the rectum and intestines.
2. Impaction of fæces, gall-stones, or foreign bodies.
3. Fibrous stricture of the intestine consequent on changes in the intestinal wall.
4. Obstruction by tumours growing from the intestinal wall.
5. Intestinal strangulation by bands, adhesions or internal hernia.
6. Volvulus.
7. Intussusception.
8. Mechanical pressure upon the bowel from without.

**Congenital malformations of the rectum and intestines.**—Malformations of the rectum are necessarily seen chiefly in new-born infants. The most common deformity is an imperforate anus or deficiency of the lower part of the rectum (see *Diseases of the Rectum*, p. 996).

The duodenum or upper part of the jejunum may be strictured, or a portion actually absent. The cause of such a condition is not known with accuracy, but it is supposed to result from atrophy following some abnormal twisting during the process of development of the bowel, or occasionally from pressure exerted by the omphalo-mesenteric duct, or a fibrous band representing its atrophied remains, forming what is called a Meckel's diverticulum. Vomiting and great distension of the stomach and duodenum are the characteristic signs, the dilatation of the latter being so great as to cause sometimes a bulging in the right iliac fossa. The correct treatment, if diagnosed early, is to perform a lateral anastomosis between the lower part of the distended

portion and the upper part of the collapsed intestine. Such cases are, however, usually fatal.

**Impaction of fæces, gall-stones, or foreign bodies in the intestine.**—An accumulation of hardened faeces may occur as the result of habitual constipation, and such accumulation is then found in the rectum and colon. There will be a history of constipation, the rectum will be found filled with scybalous masses, and the loaded colon may be felt as a distinct swelling through the abdomen, and, if so, will be soft and putty-like, and may be indented with the fingers.

The *treatment* consists in the use of purgatives and enemata, or if these means fail, the rectum may have to be emptied with a scoop or other suitable instrument. These cases may simulate the chronic obstruction due to a carcinoma low down in the rectum, and a correct diagnosis may only be possible after the impacted fæces have been cleared out.

Impaction of a gall-stone or of an intestinal concretion (*enterolith*), though more rare, is met with in the small intestine. The gall-stone usually comes from the gall-bladder, and reaches the intestine, not through the common bile-duct, but by a fistulous opening forming between an inflamed gall-bladder and a coil of small intestine to which it is adherent. The cause of the obstruction is generally only discovered after the abdomen has been opened, though some indication of the trouble may be gained from a history of previous gall-stone colic or jaundice. If the stone is not firmly impacted and the intestine not unduly injured, the stone may be manipulated through the small intestine into the cæcum, when it will be passed naturally. If it is firmly impacted, then the intestine is incised and the stone extracted. Such an incision should be made in the longitudinal axis of the bowel, not immediately over the stone, where the intestine may be weakened through ulceration, but about two inches above it. The stone is then removed, being broken up if necessary, and the incision in the intestine sutured. Should the walls of the bowel be damaged irretrievably by ulceration, then a portion may need resection, and subsequent anastomosis. Sometimes the impacted gall-stone, if soft, may be broken up by puncture with a needle without opening the bowel. If obstruction is due to a foreign body there will be the history of one having been swallowed, and it may be detected by the X-rays. Very large foreign bodies, if round, may be passed naturally, and an operation for their removal is only necessary when causing obstruction or ulceration.

**Fibrous stricture of the intestine consequent on changes in the intestinal wall.**—This is a somewhat rare condition, and results from contraction following old inflammation and ulceration. The commonest cause is dysenteric ulceration, which is usually to be found in the large intestine. Tuberculous ulceration occurs most frequently in the ileum, about the neighbourhood of the ileo-cæcal valve, and is only a rare cause of stricture.

In women, contraction following gonorrhœal or syphilitic ulceration, though rare, may be found in the rectum (see p. 977). Another rare cause resulting in fibrous stenosis of the bowel is diverticulitis of the colon (see p. 1008). The condition is generally mistaken for carcinoma.

**Obstruction by tumours growing within the bowel.**—Tumours growing from the wall of the intestine may be innocent (*e.g.*, *adenoma*) or malignant (*carcinoma* or *sarcoma*). By far the most common is a carcinoma of the columnar-celled type originating in the glandular tissue.

Two types of carcinoma are recognised clinically — one a hard, ring-like stricture, the first sign of which is usually obstruction, and the other a more massive form of growth, giving rise to a definite lump liable to undergo

colloid degeneration and less likely than the other to obstruct the bowel. The common sites for the growth of a carcinoma are the rectum, pelvic colon, cæcum, and the flexures of the colon. The small intestine is much less liable to the attacks of carcinoma than the colon.

The most prominent sign of such a growth is the obstruction to which it gives rise, though attention may be called to it previous to obstruction by pain, the formation of an abdominal tumour, or by the passage of blood and mucus *per rectum*. Secondary growths are liable to occur in the liver and internal viscera, and rapid dissemination may occur in the peritoneum, causing ascites. In dealing with such a case, the first question to be considered is the relief of obstruction, and secondly, where possible, the removal of the growth. Generally speaking, however, it is not advisable to remove the growth at the first operation, but to relieve the obstruction only and, if possible, do a resection later, because the distended condition of the obstructed bowel is not favourable to the formation of an anastomosis. The obstruction then may be relieved by the formation of an artificial anus or colostomy above the stricture, or by short-circuiting the bowel, joining the lower portion of the ileum to the colon, or transverse to pelvic colon, according to the situation of the growth. A short circuit is preferable to a colostomy for obvious reasons.

*Innocent tumours* growing on the wall of the bowel are rare. They are fibroma, fibro-myoma, lipoma, angioma, lymphadenoma and adenoma. Of all these, adenoma (intestinal polypus) is the commonest. Such a tumour grows from the mucous membrane, and is composed of glandular tissue resembling that from which it arises. They are found chiefly in the rectum (p. 1015) and colon (see p. 981). They may be single or multiple, sessile or pedunculated; they may attain a great size and so fill the lumen of the intestine. In this condition they may bleed, and also form the starting-point of an intussusception.

**Intestinal strangulation by bands or internal hernia.**—Under this heading are included a number of different anatomical conditions, all of which are alike in so far that a loop of intestine is compressed by some unyielding band, kinked by contracting adhesions or ensnared in some normal or abnormal opening and so strangulated. The strangulation may be effected by :—

1. *Bands*, which are the outcome of old inflammatory adhesions caused by infective processes such as peritonitis following appendicitis, a perforated ulcer, or subsequent on injury or operation—in fact, adhesions capable of producing strangulation may follow any form of peritonitis from which recovery has taken place. The band is usually between two coils of intestine binding down a third coil which has slipped between them. The strangulation is usually very acute, and unless relieved quickly will be followed by ulceration of the compressed piece of intestine. The treatment consists in division of the band and suture of the two extremities. In some instances, such as long-standing tuberculous peritonitis, obstruction may result from matting caused by a mass of adhesions rather than a single isolated band; such a condition is extremely hard to deal with, and will probably result in the formation of an artificial anus.

2. *Strands of omentum* with adhesions at their extremities to the abdominal wall or to loops of intestine, resulting again from past peritonitis. A loop of intestine may become twisted round such a strand and so be strangulated.

3. *The remains of some fœtal structure*, as the omphalo-mesenteric duct (Meckel's diverticulum). This structure springs from the ileum about 2 feet above the ileo-cæcal valve It may be represented as a mere bud of an inch

or two, or be patent as far as the umbilicus, forming an umbilical fistula When the cause of obstruction, it is generally in the shape of an atrophied cord, attaching the ileum to the umbilicus and forming a band under which intestine may be compressed or round which it may be twisted. Such a band requires ligature at either end and excision (see also p. 974).

4. *Strangulation in a pouch, or internal hernia.* As has been mentioned above, during the process of development of the peritoneum and intestines many pouches are left, some large and some small, about the cæcum, pelvic colon and duodeno-jejunal flexure. A loop of bowel may find its way into one of these pouches, and, if unable to get out, become inflamed and later

FIG. 392.—Volvulus of cæcum. (St. Bartholomew's Hospital Museum.)

strangulated. Diagnosis can only be established after the abdomen has been opened, when an attempt should be made to pull the affected loop out of the pouch and to close the pouch by suture. Adhesions which occur between the intestine and parietal peritoneum may make this difficult.

5. *Strangulation through a hole in the mesentery.* A slit in the mesentery is often found either due to congenital causes or resulting from injury, and through such hole a loop of intestine may be pushed and become nipped.

**Volvulus.**—This is the term applied to the intestine when it is so turned or twisted on its own mesentery as to become obstructed. The commonest site for its occurrence is in the pelvic colon, when it is followed by enormous distension of the loop. When it occurs in the small intestine many feet of

the bowel are involved, and the condition, unless diagnosed quickly and treated early, is a very dangerous one. The causes are various. In the pelvic colon it would seem sometimes to follow chronic constipation, especially when there is a long mesentery to the pelvic colon and a large loop is formed. It certainly, however, is also consequent upon fibrous adhesions, in which one part of the intestine is bound down and the other moves freely.

The occurrence of the following symptoms and signs in an adult ought to suggest the possibility of a volvulus :—

(*a*) A history, extending over a period of several years, of a number of attacks of indefinite abdominal pain or discomfort, accompanied by vomiting and much distension.

Fig. 393.—Intussusception. (St. Bartholomew's Hospital Museum.)

(*b*) The subacute onset of an attack of partial intestinal obstruction. The special characteristics of the symptoms usually present are :—

1. The attack is usually of three to six days' duration before the symptoms are sufficiently urgent to call for surgical interference.

2. The vomiting, which may completely intermit for twenty-four hours, very rarely becomes feculent, and is accompanied by more retching and straining than is usually seen in cases of obstruction due to a growth or band.

3. The obstruction is not absolute, so that enemata may bring away small quantities of flatus or fæcal material.

(*c*) The presence of a visible, globular, and tympanitic abdominal tumour, which may be observed to alter in position, and in the earlier stages can be moved about the abdomen if muscular relaxation is secured.

*Treatment.*—Immediate laparotomy with untwisting of the loop. Great care must be exercised, because the affected portion of the intestine will be found heavy and filled with fluid, and is apt to tear ; it may be necessary to incise the loop and evacuate its contents before reduction can be safely effected.

If the bowel is greatly distended and its muscular coat paralysed, a Paul's tube should be tied into the incision thus made, and the intestine itself fixed in the wound to the peritoneum and posterior rectal sheath by a few sutures.

The temporary faecal fistula thus produced usually heals spontaneously in the course of two to three weeks.

After the intestine has been untwisted a search should be made for any adhesions binding down one portion, and, in the event of temporary drainage not being necessary, it may be advisable to stitch the intestine in position to prevent twisting up again, for patients have been known to have a recurrence of the volvulus within a few weeks of the previous attack.

**Intussusception.**—In this condition a portion of the intestine is invaginated into the lumen of the bowel distal to it. The external portion is called the "sheath," "ensheathing layer," or "intussuscipiens"; the remainder, consisting of two layers of bowel, the entering and returning layers, is the intussuscepted portion or "intussusceptum." If a vertical section of an intussusception is made it will be seen to consist of six layers of intestine, three on either side of the central canal (Fig. 394), and if a circular section is made there will be found three concentric canals, one within the other. In the innermost ring mucous membrane will be applied to mucous membrane; between the middle and inner ring peritoneum is applied to peritoneum, into this space the mesentery of the intestine is dragged, and here the vessels may be compressed. The results produced by an intussusception are due to two causes: (*a*) mechanical blocking of the bowel due to the invagination; (*b*) strangulation of the intussuscepted portion due to compression of its vessels, from which gangrene may result.

The peritoneal coats which are in apposition in the intussusception soon become inflamed, and, if the condition is not relieved early, adhesions form between them, rendering reduction difficult or impossible. The intussusception, at first quite small, may extend, and ultimately the intussusceptum may protrude at the anus. That portion of the bowel first infolded, commonly ileum some 6 to 12 inches above its termination, forms the apex of the intussusception, and however far the disease progresses always remains so. The intussusceptum increases at the expense of the *entering* and *ensheathing layers* equally, the sheath gradually becoming infolded as more and more of the intestine passes onwards into the intussusception.

There are four varieties of intussusception, of which the first is by far the commonest:—

1. *Ileo-ileo-cæcal.*—In this form a portion of ileum a few inches above the cæcum forms the apex, and the intussusceptum, increasing at the expense of the ileum proximal and distal to its starting point, eventually enters the cæcum. When all the distal portion of the ileum has been used up in this way there is usually a slight delay, and then the cæcum, carrying the appendix with it, turns in and the colon is gradually rolled up into the swelling.

2 *Ileo-cæcal*, in which the ileo-cæcal valve is the starting point and forms the apex.

3. *Colic*, in which a part of the large intestine forms the apex, colon being invaginated into colon.

4. *Enteric*, in which small intestine only is involved.

It is probable that the *ileo-colic* variety formerly described, *i.e.*, one in which more and more of the ileum pass onwards through a stationary ileo-cæcal valve with the constitution of its apex constantly changing, does not occur. Its existence pre-supposes a method of formation entirely at variance with that of all other known varieties. It is necessary to assume that the cæcum, which in this case is the ensheathing layer, takes no part in the gradual increase of the intussusceptum, and this at the narrowest part of the intestine, the ileo-cæcal opening, which of all others would be most unlikely to remain a stationary point.

*Causation.*—In most cases there is no explanation forthcoming. It is supposed to arise in connexion with irregular peristalsis caused by injudicious feeding, worms, and aperients. It seems to be most common at certain periods of the year, such as Christmas and Easter, a fact which lends some support to the theory of improper feeding. The condition is most common in infants and young children under the age of four. It is associated sometimes with Henoch's purpura, and effusion of blood into the bowel. In adults, in whom the condition rarely occurs, the intussusception has been caused by the dragging of a polypus or carcinoma.

*Symptoms and signs.*—The first sign is pain, as indicated in infants by incessant crying and refusal of food. Vomiting is prominent and persistent and there is complete obstruction to the passage of flatus and fæces, but in addition to these cardinal signs of intestinal obstruction blood and mucus may be passed by the bowel. This is an important diagnostic sign, and the surgeon should never neglect to examine the diaper of an infant suspected of intussusception. There may also be the presence of a sausage-shaped tumour lying across the abdomen, and a hyper-resonant note on percussion in the right iliac fossa, denoting a displacement of the cæcum. In advanced cases a rectal examination may reveal protrusion of the intussusceptum through the anus.

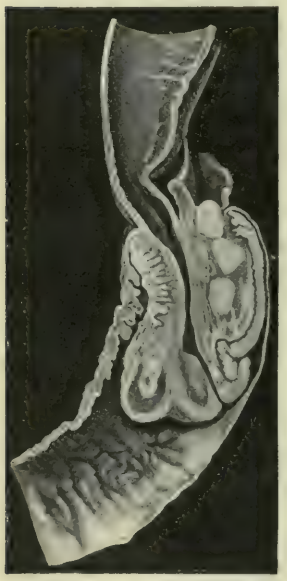


Fig. 394. — Intussusception. (Westminster Hospital Museum.)

A *differential diagnosis* is to be made from other conditions in which blood and mucus are passed, the most important of which is the summer diarrhœa of infants, in which large quantities of blood are passed and the infants are very ill.

*Pathology.*—The hæmorrhage and discharge of mucus are due to the congestion of the intussuscepted portion brought about by the invagination and constriction of the mesenteric vessels. If the condition goes on too long, adhesions may form between the peritoneal surfaces and the intussusceptum may become gangrenous.

Spontaneous cure, though rare, may occur in one of two ways—either the intestine may right itself by its own efforts, or the whole of the indrawn loop may die and be discharged as a slough per rectum, cure being effected by the peritoneal surfaces adhering and a spontaneous end-to-end anastomosis resulting.

*Treatment.*—This must be prompt, for small infants, who are the usual sufferers, withstand intestinal obstruction very badly, whereas if the condition is recognised and treated within twenty-four hours of the onset of the trouble there is every chance of curing the patient. There is one thing to do, namely, to open the abdomen and reduce the intussusception by manipulation; all methods previously in use, such as distension of the lower bowel by injections of fluids or gas, having been given up in favour of operation. In attempting to reduce an intussusception the invaginated portion should be squeezed, rather than pulled, out of the sheath by exerting pressure just beyond the apex after straightening out the sausage-

shaped tumour as much as possible. The hardest part to reduce is the last piece, which was the first to be invaginated, and therefore suffers more and is apt to be swollen and congested, or sometimes adherent. A combination of gentle pull and squeeze may be required to free it, but great care must be exercised, for the intestine tears readily. A great obstacle to the reduction of this last portion is often the narrowness of the ileo-cæcal opening. This can be overcome by invaginating the proximal portion of the bowel and passing two fingers along the central lumen of the intussusception until the constricting ring is reached, and then gently dilating the latter. Supposing that it is impossible to reduce the intussusception, there are three courses open to the surgeon :—

1. Resection, followed by an intestinal anastomosis.
2. A short circuit by lateral anastomosis.
3. The formation of an artificial anus without reduction.

No great success has attended any of these measures, and they must be regarded as desperate remedies.

If it is found necessary to resect a gangrenous portion, the sheath and entering-tube are united at the neck by a continuous suture. A longitudinal incision is then made through the sheath and the gangrenous portion removed, the outer sheath being again closed by suture. Should the whole mass be gangrenous, then the only method available is resection.

**Chronic intussusception.**—This is more common in adults than in infants. It gives rise to anomalous symptoms and is generally only recognised after the abdomen has been opened. A swelling is generally found in the abdomen, and it may be mistaken for a carcinoma of the bowel or an enlarged kidney. It may be dealt with by resection followed by anastomosis, or perhaps in a better way by a simple short-circuiting operation. Little is known about the origin of such a condition, though, as has been mentioned above, the apex of such an intussusception may be formed by a polypus, carcinoma or an invaginated caseous mesenteric lymph gland, which apparently has exercised a dragging influence.

**Mechanical pressure upon the bowel from without.**—As examples of this may be cited tumours starting outside the bowel and by their large size pressing on and obstructing it, such as an impacted ovarian cyst or fibroid uterus, or a malignant growth originating in the bones. An appendix abscess situated in the pelvis may be large enough to cause complete intestinal obstruction. Such an obstruction is not acute in its onset, and is commonly preceded for several days by a discharge of mucus, which is sometimes blood-stained, from the rectum.

## Varieties of Intestinal Obstruction due to Paralysis.

There are a number of conditions in which signs of intestinal obstruction occur without there being any mechanical cause. It is mentioned in the discussion of *Peritonitis* that intestinal stasis occurs as a result of paralysis due to poisoning by toxic products. Another condition, giving rise to similar appearances, is *embolism and thrombosis of the mesenteric vessels*. Either the mesenteric vein or artery may be occluded, and the results, both clinically and pathologically, are much the same, resulting in gangrene of portions of the small or large intestine. This condition is usually associated with some disease such as cirrhosis of the liver, endocarditis, or mitral stenosis. The symptoms of acute intestinal obstruction appear suddenly, and in addition a large amount of blood may be passed by the bowel. On opening the abdomen

blood-stained fluid will be found in the peritoneal cavity, and the affected portion of intestine will be found dark-coloured, swollen and œdematous, and thrombosed mesenteric veins may stand out as dark blue cords. The condition usually proves fatal, and the only method of treating it is by resection of the affected loop of the bowel, provided the serious condition of the patient will allow it.

Other conditions which simulate intestinal obstruction very closely, and are often diagnosed as such, are—a twisted viscus, such as an ovarian cyst or testis, a strangulated portion of great omentum, or the condition known as acute hæmorrhagic pancreatitis.

**Entero-spasm.**—The term "entero-spasm" is given to a condition in which attacks of colic or symptoms suggestive of intestinal obstruction arise as the result of spasmodic contractions of the circular fibres of a segment of bowel. The patient is seized with severe abdominal pain, accompanied by vomiting and stoppage of the passage of flatus and fæces. This may pass off rapidly, but often is so severe that the abdomen is opened under the belief that there is some mechanical obstruction, and nothing is found but a section of intestine in a state of spasmodic contraction.

In addition, the symptoms may be more or less chronic, suggesting the presence of a carcinoma of the bowel, accompanied by an occasional partial blockage. Regulation of the diet and the bowels will generally be sufficient to clear up the diagnosis.

### Affections of the Small Intestine.

**Congenital abnormalities.**—The continuity of the small intestine may be interfered with by the formation of a septum or constriction, due probably to some faulty development, and sometimes there may be complete absence of an entire segment of the intestine and its mesentery.

*Meckel's diverticulum* is a congenital abnormality of the small intestine due to the persistence of a portion of the vitelline duct. It usually shows itself as a small bud or finger-like projection springing from the free border of the ileum about 2 feet above the ileo-cæcal valve. In other cases it may persist as a patent tube as far as the umbilicus (see p. 879), or the terminal portion may become atrophied into a cord-like band and be a fertile cause of intestinal obstruction (see p. 968). In a few instances it is recorded that such a diverticulum acted in a similar manner to the appendix, having become inflamed owing to the accumulation of fæcal material. The *treatment* consists in its removal, supposing it to be the cause of any trouble.

**Tuberculosis.**—The part most usually affected is the lower end of the ileum, infection having occurred from bacilli swallowed with the sputum, or in milk or other food, lodging in the Peyer's patches and lymphoid nodules. Small, irregular ulcers form in the mucous membrane tending to spread in a circular direction around the bowel. As they heal cicatricial contraction may form and give rise to a stricture, though, as has been mentioned before, this is not a common occurrence. The disease, though it may be limited to the mucous membrane, frequently spreads to the peritoneal surface, miliary tubercles being formed at the back of the ulcer and the associated mesenteric glands becoming enlarged and caseous. In some cases there is a great reaction to the inflammation with the formation of a large amount of fibrosis, which is sufficient to form a swelling palpable through the abdominal wall (hyperplastic form). This occurs usually in the neighbourhood of the ileo-cæcal valve, and the resulting swelling may be sufficient to cause a partial intestinal obstruction,

or an abscess may form, become secondarily infected from the bowel, and burst either into the peritoneal cavity, causing septic peritonitis, or on the surface of the skin, leaving a fæcal fistula (see also p. 892).

The *diagnosis* is to be made from chronic appendicitis, for which it is often mistaken, and from a slow-growing carcinoma of the cæcum. Compared with the latter the progress of the disease is slow, and there are periods of quiescence and recrudescence. On opening the abdomen, if there is any difficulty in making a diagnosis, one of the enlarged glands in the mesentery is removed and submitted to histological examination.

As regards *treatment*, no dogmatic statement can be made, though, if the swelling is large enough to cause obstruction, the ileo-cæcal segment should be removed much on the same lines as for carcinoma, or if sinuses and fistulæ render this impossible, a short-circuiting operation should be done, the lower end of the ileum being implanted into the transverse or pelvic colon. Localised masses of caseous mesenteric glands may be removed.

**Typhoid ulceration.**—In the course of typhoid fever perforation of an ulcer is met with in a small percentage of cases. The ulceration generally occurs in the second or third week, and the ulcer which perforates is usually situated in the ileum within 2 or 3 feet of the cæcum.

*Diagnosis.*—This is often extremely difficult, owing to the serious condition of the patient, who is already suffering from abdominal pain and raised temperature and pulse-rate. The symptoms are a sudden access of acute pain, referred to the lower part of the abdomen, with tenderness on pressure, muscular rigidity, and increase of distension, associated with vomiting and other symptoms of acute infective peritonitis. Very similar symptoms are caused by a hæmorrhage from such an ulcer, and it may be very difficult to decide between the two. An examination of the blood is often of great assistance, for in typhoid fever there is a reduction rather than an increase in the number of white cells, and very shortly after a perforation a leucocytosis occurs. If there is any doubt as to the diagnosis an exploratory laparotomy should be made, as experience proves that success depends on an early operation.

*Treatment.*—An incision is made in the mid-line of the abdomen below the umbilicus, the cæcum identified, and the lower part of the ileum examined. The perforation, when found, is closed with Lembert's sutures and then a search made for any other perforation which may be present; any suspicious thin area is invaginated with a purse-string suture or covered with an omental graft.

In severe cases the bowel may be found actually gangrenous, in which event the affected portion must be resected, or, if the patient is unable to stand such a severe operation, a loop of intestine is brought to the surface and an artificial anus formed.

**Tumours of the small intestine** are very rare. They may be innocent, *e.g.*, lipoma, fibroma, myoma or adenoma, or malignant. Carcinoma of the ileum or jejunum is rare, but in the neighbourhood of the opening of the bile-duct into the duodenum it is somewhat more frequent.

**Actinomycosis.**—The cæcum and appendix are the most common positions for actinomycosis in the intestine. Infection occurs through the mucous membrane and spreads to the surrounding peritoneum and intestines; it gives rise to an indurated swelling, which later suppurates and tends to form one or more sinuses, in the discharge from which the characteristic ray fungus may be found. The disease is extremely chronic and difficult to cure. The *treatment* consists in opening and irrigating the abscess cavity and in the administration

of large quantities of potassium iodide, together with ionisation and the use of radium and X-rays.

**Enteroptosis, or Glénard's disease** (see also p. 944).—In this condition there is a laxity and stretching of all the suspensory ligaments of the abdomen com-

Fig. 395.—Pedunculated adenomata of small intestine.
(St. Bartholomew's Hospital Museum.)

bined with loss of tone of the abdominal muscles, resulting in a downward displacement by gravity of all the abdominal contents, including the intestines, stomach, liver, spleen, and kidneys. The chief complaints are of a dragging sensation in the abdomen, which is made worse by exercise and relieved by lying down, dyspeptic symptoms, constipation, and neurasthenia. The condition may be aggravated by the presence of a hernia or of an abnormally movable kidney. On examination the lower part of the abdomen is found unduly prominent, and there may be evidence of prolapse of the stomach and

DIVERTICULITIS.

Part of a pelvic colon which has been divided longitudinally to show numerous diverticula, with marked narrowing of the lumen due to fibrous thickening of its wall. (St. Bartholomew's Hospital Museum.) (From *The British Journal of Surgery*.)

colon. The *treatment* is directed towards improving the general health and muscular tone by massage and suitable exercises, and the Weir-Mitchell treatment; also some form of mechanical support, such as an abdominal belt, may be worn to supplement, but not to take the place of, the abdominal muscles. Operative interference is not called for, for if such movable organs are fixed up the relief is not usually a lasting one.

### Affections of the Colon.

**Congenital idiopathic dilatation of the colon: Congenital megalocolon or Hirschsprung's disease.**—This is a condition in which the whole of the colon is enormously dilated and hypertrophied without there being any mechanical obstruction to the bowel, and it is characterised clinically by extreme constipation, amounting often to intestinal obstruction, associated with progressive distension and enlargement of the abdomen. The condition is generally found in young children in whom, from the time of their birth, there has been extreme difficulty in movements of the bowels, and who have had to depend for an action on purgatives and enemata. The rectum and anus are usually normal, the dilatation starting from the lower part of the pelvic colon, which may form an enormous loop many inches in diameter filling the greater part of the abdomen, and extending to the transverse and ascending portions of the colon, the small intestine not being affected. If a section of the intestines is cut there is found to be great weakening of the circular muscular coat and an increase of fibrous tissue in all the coats.

The cause of the condition is not known with accuracy, but it is suggested that the muscular coat of the intestine loses its tone owing to distension following bacterial infection and formation of gases; the distended bowel may become bent or kinked to such an extent as to fold over on itself or press on the upper part of the rectum, forming thus an obstructive kink or valve. Temporary relief is furnished by the use of enemata and massage of the abdomen combined with irrigation of the bowel to remove products of decomposition; generally speaking, however, such patients relapse when not under constant medical supervision, with the result that grave features supervene and the growth and well-being of the child are seriously impaired. If such medical means fail to give relief, recourse must be had to surgery.

In cases of urgency a colostomy is indicated, and such an operation will often yield complete relief.

Division of the ileum and transplantation of the upper end into the sigmoid (ileo-sigmoidostomy), so as to short-circuit the large intestine, has not proved a great success, because fæcal material still tends to accumulate in the greatly-dilated intestine. The only radical means of surgical treatment is a severe one involving removal of the whole of the large intestine, the ileum being implanted into the pelvic colon.

**Diverticulitis.**—Diverticulitis of the colon when first described was regarded as a pathological curiosity, but is now recognised as a clinical condition which is by no means rare. The condition has in the past been frequently mistaken for inoperable carcinoma with inflammatory sequelæ. Diverticula are more often met with in the colon than elsewhere, and, when they occur, are liable to give rise to inflammatory mischief because they tend to harbour fæcal material. Although no part of the large bowel is exempt, the pelvic colon is the seat of election. It is in this situation that the symptom complex of diverticulitis (*sacculitis* or *sigmoiditis*) is prone to occur.

The origin of these intestinal pouches is not yet satisfactorily established, but it is possible that increased pressure within the colon is the most important factor, due to constipation and flatulent distension. Other possible causes are straining at stool and resistance to the natural call for evacuation. The pouches begin as minute hernial protrusions of the mucous membrane through the circular muscle. As they enlarge they tend to become flask-shaped and bottle-necked, and are most commonly met with on either side of the longitudinal band of muscle which runs along the mesenteric border. They are prone to form at points where the arteries pierce the muscular coat to supply the mucosa, *i.e.*, at the weakest points in the musculature. Not infrequently they thread their way into the loose fat of an appendix epiploica following the arterial branch to the appendage. In size the sacculi range from a grape seed to a grape; they may be few in number and scattered, or numerous and involve either a large area of the colon or be confined to the pelvic colon. Most commonly the pelvic colon is alone involved.

The great majority of the cases occur in the middle-aged or old, and the condition is usually associated with an excess of fat in the extraperitoneal tissues. The small size of these pouches, coupled with the fact that they occur in fat-laden bowel and are frequently hidden in the appendices epiploicæ, explains why they often escape detection. Diverticula are frequently seen at autopsies, and it is probable that often they fail to give rise to any serious symptoms. When fæcal matter, retained in one of these pouches, becomes dried up and forms a concretion, ulceration may occur and be followed by (1) perforation and local or general peritonitis, (2) peri-diverticular suppuration, (3) peri-diverticular fibrosis, or (4) adhesions and subsequent fæcal fistula.

When the contents of one or more diverticula give rise to irritation and inflammation, secondary changes supervene which are analogous to those resulting from inflammation of the vermiform appendix, and the clinical symptoms correspond also to those of appendicitis in its varying phases, so that the condition has been described as "left-sided appendicitis." If, however, inflammation around diverticula results in a chronic *hyperplasia* and tumour formation, the condition is ofien confused with malignant disease.

When fibrosis occurs, the walls of the colon become very thick, and a sausage-shaped tumour results. Fibrosis is followed by stenosis, stenosis by obstruction, and the mimicry of cancer seems complete. In rare instances carcinoma has been proved to follow diverticulitis, and the latter is sometimes met with above a carcinoma. With adhesions to the bladder a vesico-colic fistula is not uncommon, and recent research shows that diverticulitis is more often responsible for fistula into the bladder than malignant disease.

*Diagnosis.*—When signs and symptoms analogous to those of appendicitis occur on the left side, diverticulitis may be suspected, especially in stout people past middle age. Careful examination with X-rays after a bismuth meal, which may be aided by a bismuth enema, may reveal the presence of diverticula.

If a tumour is present, diverticulitis may be suspected rather than carcinoma when there is a long history of flatulent distension and constipation without the presence of blood in the stools and the patient is well covered and has not lost flesh.

Should there be definite inflammatory attacks with occasional rises of temperature, perhaps associated with a rigor, with a history that the tumour disappears or subsides after the attacks, then a diagnosis of diverticulitis is still more likely.

As already stated, diverticulitis may exist in the colon without giving rise to symptoms.

*Treatment.*—When, as the result of fæcal stasis in one or more pouches, acute or subacute inflammation occurs around the diverticula, suppuration may follow, producing an abscess, perforation or adhesions. Under these conditions treatment on parallel lines to that for infective conditions in connexion with the appendix will be required.

When the inflammation is chronic and results in fibrosis and stenosis, then operation may be necessary to relieve symptoms of obstruction. The ideal operation is to resect the involved area of the pelvic colon, but in practice this is seldom advisable. Inflammation and adhesions add considerably to the risk of resection, and often the mesentery and colon are so loaded with fat that the difficulties are considerable. In these circumstances a temporary colostomy is advisable, and if the involved pelvic loop is long enough, it may be brought outside the abdomen and resected some days later when shut off from the peritoneal cavity. When the area involved is not extensive, the inflammatory condition may subside after a temporary colostomy. After resection and colostomy a subsequent extraperitoneal anastomosis may be possible, or if not, a short circuit with the transverse colon.

The condition has been known to recur after a direct anastomosis, and it is an open question whether it is not wiser to suffer the inconvenience of a permanent colostomy.

**Colitis.**—This term is applied to a condition causing a recurrence of colicky pains associated with diarrhœa and the passage of large quantities of mucus from the bowel. There may be mere catarrhal inflammation only or in more severe cases actual ulceration; if present, the ulcers vary in size from a minute patch to an almost complete destruction of the whole of the mucous membrane, and are accompanied sometimes by copious hæmorrhage, due to erosion of a large artery. During an attack pressure over the colon causes a good deal of pain, and the bowel may be felt to contract under the fingers, forming a firm, elongated, sausage-shaped swelling. If the mucous membrane of the colon is examined with the sigmoidoscope, it may be found in the slighter cases normal, or inflamed with small petechial hæmorrhages, or ulcerated. Usually some small patches of thready mucus are found hanging to the wall, and small crypts are seen containing particles of fæcal material. The mucus is sometimes clear, like the white of an egg, sometimes in flaky shreds, or it may take the form of fibrinous casts of the bowel many inches long. Blood may be present in the motions, and occasionally intestinal sand, composed of stearate of calcium. The patients usually waste very considerably, and become very depressed, owing to the frequent recurrence of attacks.

*Differential diagnosis.*—The diagnosis of colitis should not be made until the other conditions which closely simulate it have been excluded. The local symptoms are usually referred to the pelvic colon, but if in the right iliac fossa the condition may be extremely difficult to distinguish from chronic appendicitis. All the symptoms are very similar to those of dysenteric ulceration, but it is distinguished from it by the fact that the amœba or bacillus of dysentery is not present in the stools and that the patients have not been subjected to dysenteric infection. Other conditions to be excluded are malignant disease, tuberculous ulceration of the intestine, and abscess in the vicinity of the colon.

*Treatment.*—This is at first medical, and operative interference should only be employed when these methods have been well tried and failed. The first means are dietetic, and it seems generally agreed that the diet should be

a full one, consisting of such things as fruit, brown meal, vegetables, and butchers' meat, which leave a considerable residue. The fæces should be rendered soft by the addition of fatty materials to the diet and constipation prevented by the administration of petroleum emulsion and enemata. The bowel should be well washed out daily with warm olive oil and saline solution, and inflammation of the mucous membrane may be allayed by irrigation with some albuminous silver preparation such as protargol. When such measures are ineffectual operative interference becomes necessary, and a choice has to be made between appendicostomy, a short-circuiting operation, *e.g.*, ileo-sigmoidostomy, and excision of the large intestine.

The object of an appendicostomy is to furnish a better means of irrigation of the colon than can be managed from the rectum. For this purpose the appendix is brought to the surface of the body through a small incision in the right iliac fossa and a small calibre rubber catheter inserted: through the catheter several pints of warm water or saline solution are run into the bowel as often as desired, and the patient can perform the manœuvre easily without aid. In a certain number of cases this is sufficient.

Short-circuiting is done by implanting the lower end of the ileum into the pelvic colon, circulation of the intestinal contents through the cæcum being prevented by division of the ileum. This method is open to the objection that a long *cul de sac* is left, in which large quantities of fæcal material may accumulate, the fluid fæces discharged by the ileum finding an easier passage up into the colon than down into the rectum.

The most radical operation of all, but one attended with considerable risk to the patient, is excision of the whole of the large intestine. The use of a bacillus-coli vaccine has met with success in some cases.

**The operative treatment of habitual constipation and intestinal stasis.**—In the last few years considerable attention has been directed to kinks of the large intestine caused, either by the contraction of adhesions, or by prolapse and folding of the colon over normal or abnormal ligaments of the peritoneum, with the result that a condition of habitual constipation supervenes associated with the continued absorption of small doses of toxins and perhaps bacteria into the blood-stream. The general health of such patients is apt to suffer, and it is suggested that this condition may be the cause of the many chronic ailments, such as arthritis, mastitis and some forms of neuritis, which now are commonly attributed to some chronic bacterial infection. If the ordinary medical means consisting of regulation of the diet and the use of purgatives and laxatives fail to give relief, operation is advised by some surgeons, and the two methods advocated are—(1) ileo-sigmoidostomy, and (2) excision of the colon, the ileum being implanted into the sigmoid flexure.

Short-circuiting the colon alone or ileo-sigmoidostomy has not proved a great success. If the operation is done by lateral anastomosis without division of the ileum very little advantage seems to be gained, for the fæces still appear to pass straight through into the cæcum; if on the other hand the ileum is divided and implanted into the sigmoid flexure the large open colon is still left and, acting like a cesspool, allows the accumulation of large quantities of fæcal material, so that intestinal stasis is apt to occur in even a worse form. Therefore if any operation is undertaken the only radical method is excision of part or of the whole colon. This of necessity is a severe operation, though in the hands of those skilled in it the mortality is not great.

The value of the operation and the necessity for it is still *sub judice*, some surgeons regarding the large intestine as a useless and dangerous vestigial remainder and others as a useful adjunct to health. Under these circum-

stances it must be the duty of the practitioner to weigh carefully the disability and inconvenience of the patient before advocating an operation which necessarily must be a severe one.

## Tumours of the Colon.

*Innocent tumours* are of only rare occurrence. They are adenoma, lipoma, myoma and fibroma, the last three being pathological curiosities.

Adenoma generally takes the form of a pedunculated tumour and causes little trouble; it may be single or multiple, and if the latter may be the cause of pain, diarrhœa, and the passage of blood.

*Malignant tumours.*—These are carcinoma and rarely sarcoma.

**Carcinoma of the colon.** — The commonest form of tumour is a columnar-celled carcinoma, and its most frequent sites are the pelvic colon, the cæcum, and the splenic and hepatic flexures.

There are two main types of carcinoma—(1) the commoner, a small hard ring-like growth causing a stricture of the intestine, the first symptom of which may be the intestinal obstruction to which it gives rise; and (2) a more massive form, in which a large tumour, liable to undergo ulceration and colloid degeneration, tends to disseminate in the mesenteric glands, the peritoneum and liver.

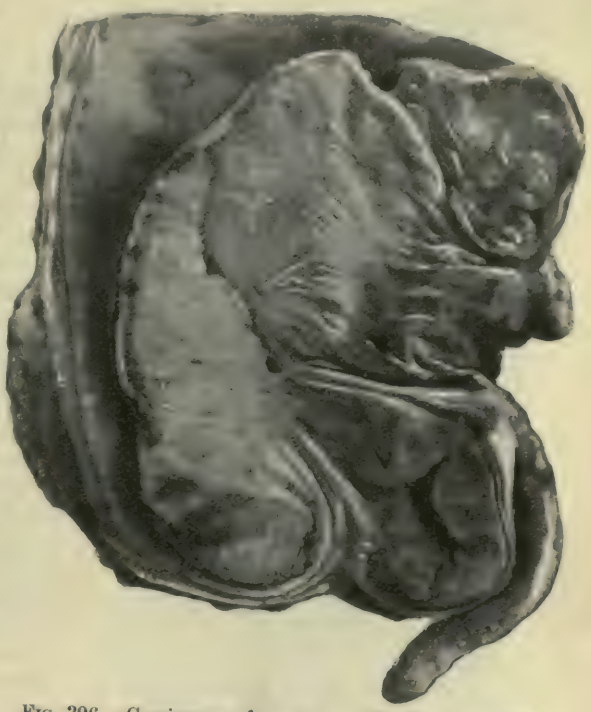


FIG. 396.—Carcinoma of cæcum. (St. Bartholomew's Hospital Museum.)

*Clinical signs.*—The patient may complain of very little beyond colicky pains in the abdomen and some irregularity of the action of the bowels, symptoms which do not excite at first any particular attention and are commonly put down to constipation. Suspicion should, however, arise if a patient over fifty years of age, previously of regular habits as regards the evacuations, should begin to complain of pain and constipation, associated perhaps with periods of diarrhœa. Such a case should be investigated with the greatest possible care: the stools should be searched for mucus and blood and the abdomen palpated carefully for the presence of a lump, an anæsthetic being administered if necessary, to overcome abdominal rigidity and to allow of a complete examination. Before doing so, however, the bowels should be well cleared so as to avoid confusion with a fæcal accumulation.

Of late years considerable improvements in methods of diagnosis have taken place following the use of X-rays combined with bismuth meals or bismuth enemata, and it is possible that an obscure case can be cleared up by these means. The interpretation, however, of pictures obtained in this way is not without difficulty, and mistakes between the appearances resulting from a physiological block and a mechanical obstruction are not uncommon. The only really reliable method of making a diagnosis in doubtful cases is by exploratory laparotomy.

*Diagnosis.*—The diagnosis is often only made after the abdomen has been opened for intestinal obstruction, and by that time it is commonly found that any form of radical operation is impossible on account of the extension of the growth and the formation of secondary deposits. Efforts of clinicians must be directed, therefore, towards making an early diagnosis at a stage when excision is still possible. This is extremely difficult on account of the vagueness of the symptoms complained of and the late stage at which patients present themselves for treatment.

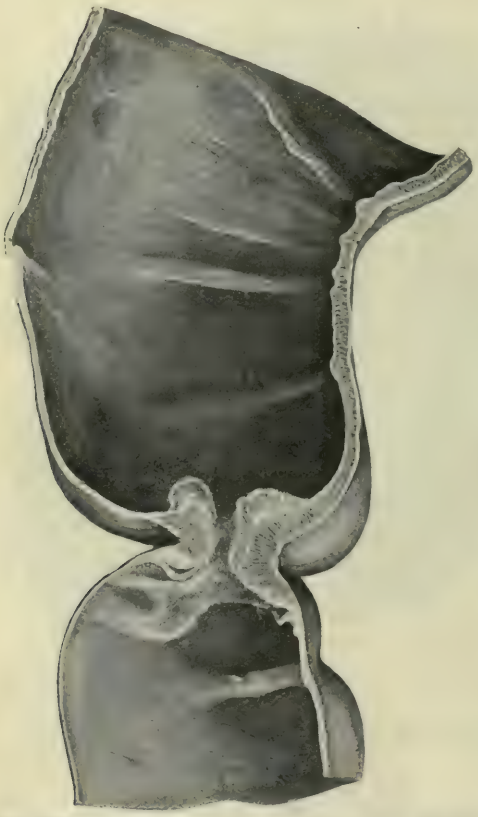


FIG. 397.—Annular carcinoma of the colon causing intestinal obstruction. (St. Bartholomew's Hospital Museum.)

*Treatment.*—Excision of the growth together with the affected glands is the only radical way of dealing with the disease, and is the method to be aimed at if circumstances permit.

Of late years the mortality of this operation has been greatly decreased by adopting the great principle of mobilisation of the colon; by this procedure the affected portion of the bowel can be brought completely out of the wound, and resection and anastomosis carried out comparatively safely and easily. The peritoneum lining the posterior abdominal wall on the outer aspect of the colon is first incised, and then by blunt dissection the intestine, together with the neighbouring fat and lymphatic glands, are gradually stripped medianwards until the bowel remains attached only by an inner leaf of peritoneum carrying its blood and lymphatic vessels, and can be readily delivered out of the abdominal cavity. The lymphatic glands draining the colon lie along the course of the blood-vessels, and in order to ensure their complete removal it is well to ligature the main arteries close to their origin from the aorta, taking care to remove subsequently all that segment of bowel supplied by them.

To take a concrete example:—In carcinoma of the cæcum, the latter with the ascending colon is first mobilised and lifted out of the abdomen. The common stem of the right and ileo-colic arteries is ligatured close to its origin from the aorta, and then resection of the last 6 inches or so of the ileum, the cæcum, the ascending colon, and roughly the proximal third of the transverse colon performed. The operation is completed by making two blind ends and anastomosing the ileum and transverse colon by a side-to-side union.

If, on account either of the presence of intestinal obstruction or of extension of the growth and the formation of secondary deposits, a primary excision is not possible, relief may be given either by means of a colostomy or of a short-circuiting operation.

*When associated with intestinal obstruction.*—In such an instance the life of the patient is in immediate danger, and the primary object must be to relieve the obstruction, which can be done most simply and effectually by the formation of a colostomy. Subsequently, after the patient has recovered from the effects of the obstruction, a second operation may be done for the complete removal of the tumour. In the case of the pelvic or transverse colon, an alternative method is to bring a portion of bowel containing the growth outside the abdomen and fix it to the wound, the obstruction being relieved by inserting a Paul's tube into the proximal limb of the loop. It is a simple matter to cut away the whole of the loop and its exposed mesentery with scissors a few days later. In some instances, in which the signs of obstruction are of a very chronic character and the intestine is not unduly distended, the disagreeable results of a colostomy may be avoided by a short-circuiting operation, either the ileum being anastomosed to the colon beyond the growth or colon being joined to colon.

FIG. 398.—Carcinoma of colon. (St. Bartholomew's Hospital Museum.)

*When unassociated with intestinal obstruction.*—1. If the growth, owing to direct extension or wide dissemination, is considered to have progressed beyond the power of removal, then the only available methods are either colostomy or a short circuit: naturally the latter is preferable if it can be managed.

2. If the growth is considered operable, there are two courses open:—

(*a*) The operation may be done in two stages, the first stage consisting in either a short-circuiting operation or a colostomy, to be followed in a week or two by the second part, which consists in the removal of the growth.

(*b*) The operation may be done at one sitting, the growth being excised and the bowel united either by an end-to-end or side-to-side anatomosis.

The mortality from either of these procedures is considerable, and is due in great measure to sepsis and soiling of the peritoneum during the manipulations in removing the growth. It would seem to be generally agreed at the present time that the way with the least risk to the patient is to do a preliminary short-circuiting operation and then at a second sitting about two weeks later to open the abdomen again and resect the growth.

**Fibrous stricture of the colon** is very rare; it may follow on an old dysenteric ulceration or occur in those occasional cases in which a foreign body such as a fish-bone has given rise to ulceration of the mucous membrane.

## The Vermiform Appendix.

The appendix may be regarded as a vestigial remainder of the much larger cæcum of animals. It forms a short blind tube of an average length of 3 inches, completely covered by peritoneum with its own proper mesentery, and situated at the inner and posterior side of the cæcum about an inch below the ileo-cæcal junction. It may lie in many positions, but the three following are the common ones :—

1. Pointing upwards towards the left shoulder;
2. Lying over the brim of the pelvis;
3. Behind the cæcum and pointing to the right side.

In addition it may enter any of the many peritoneal pouches about the cæcum. In order to find the appendix at an operation a longitudinal muscular band of the cæcum is followed down to its extremity; this is a good guide, for it leads straight to the base of the appendix, and is continuous with its muscular coat : another method is to find the ileo-cæcal junction, which is immediately above the region of the appendix. The artery to the appendix runs along the free border of the mesentery and is liable to be kinked when the appendix is twisted. The mucous membrane of the appendix is lined by columnar-celled epithelium, and in the sub-mucous coat there is a large quantity of lymphoid tissue.

### Diseases of the Appendix.

I. **Inflammation due to bacterial infection** :—

(*a*) With pyogenic organisms. (*b*) Tubercle. (*c*) Actinomycosis.

II. **Malignant disease.**

### Inflammation due to bacterial infection with pyogenic organisms.

**Etiology.**—In the vast majority of cases appendicitis is due to an infection of the mucous membrane and coats of the appendix by pyogenic organisms, the extent of the inflammation varying in degree from the merely superficial inflammation of the mucous membrane (catarrhal inflammation) to such an intense form that the whole organ becomes gangrenous, allowing escape of the contents and infection of the peritoneal surface.

*Age incidence.*—The commonest age is between twenty and thirty, though neither the very young nor the aged are exempt.

**Bacteriology.**—*Bacillus coli communis* is by far the commonest organism present, and is found not only in the lumen of the appendix, but also at the site of perforation, on the exterior of the appendix, in the abscess and diffused throughout the general peritoneal cavity (R. M. Vick). It may occur alone, but is more often in combination with others, notably *streptococci* and

INFLAMMATION OF THE APPENDIX VERMIFORMIS.

The upper figure shows in hemisection an inflamed and thickened appendix with its distal portion surrounded by omental adhesions. The left lower figure shows in hemisection a gangrenous appendix with a fæcal concretion impacted near its junction with the cæcum. The right lower figure shows in hemisection an inflamed, thickened and kinked appendix with a concretion occupying its distal end. (St. Bartholomew's Hospital Museum.)

anaerobic micro-organisms. Other bacteria which may be present, but only rarely, are *bacillus pyocyaneus*, *bacillus proteus* and the *pneumococcus*.

Experience teaches us that when the *bacillus coli* is associated with the *streptococcus* the disease is of a more severe type than when it is present in pure culture. Most of these organisms are found normally in the appendix, so that it is not merely their presence which gives rise to the trouble; there is obviously some other factor. This is put down commonly to retention of fæcal and mucous contents, the emptying of the appendix being prevented by some condition such as a twist or a kink, a stricture of the lumen caused by some old inflammation, or to a small fæcal concretion blocking the lumen. The contents of the appendix, unable to be discharged into the bowel, undergo decomposition; inflammation is set up, and appendicitis is the result. A foreign body sometimes, though rarely, seems to be the exciting cause, and many instances are recorded in literature in which a pin, a piece of porcelain enamel, or a hair, and also intestinal parasites have been found in the appendix. The disease appears often to come on without rhyme or reason, those who appear to be in perfect health being smitten down. Occasionally it seems to bear some relation to an indiscretion in diet, and it is attributed by some to excessive eating of meat. It is a curious fact that the disease, which appears to be becoming more common in civilised countries, is seldom met with in India and Africa; even when full value is given to the fact that the condition is better recognised than it was twenty years ago, when cases of appendicitis were attributed to perityphlitis and peritonitis, it must be admitted that the disease is becoming more common.

**Symptoms and Signs.**—The characteristic features of the disease are abdominal pain and tenderness in the right iliac fossa, rigidity of the lower part of the abdomen and vomiting associated with a rising temperature and pulse-rate.

*Pain.*—This is the earliest symptom, and is almost always recorded. It varies from an acute spasmodic pain associated with vomiting and sweating to a diffuse ache referred to the region of the umbilicus, becoming gradually localised in the right iliac fossa.

*Tenderness* to palpation in the right iliac fossa is always present: it may be confined to this region or even to a particular spot, McBurney's point (a spot 1½ to 2 inches from the anterior superior spine of the ilium on a line between it and the umbilicus), or in the worst cases tenderness may be generalised. On account of this the patient usually lies in the dorsal position with the legs drawn up so as to relax the abdominal muscles, or if tenderness is localised to the right iliac fossa with the right leg only drawn up.

*Rigidity.*—This sign varies much: if the trouble is confined to the appendix the rigidity may be limited to the right iliac fossa, the contracted right rectus muscle guarding the inflamed spot. If there is local peritonitis rigidity is more marked, and with spread of peritonitis may extend to the lower part of the abdomen or become general, the whole abdomen becoming hard, like a board.

*Vomiting* is a prominent symptom present in the large majority of cases. In cases of a severe type the vomiting coincides with the onset of abdominal pain, and from that time is continuous and persistent, bearing no relation to the taking of food, but accompanied by nausea. In less severe cases vomiting, though present as an initial symptom together with pain in the right iliac fossa, is not prominent in the subsequent days of attack. In the very mild cases there may be no history of vomiting or even of nausea.

*Temperature.*—Pyrexia is present in all cases at the onset of an acut

attack, and in some instances, especially in children, the disease is ushered in by a rigor and a rapid rise of temperature to 104° F. or 105° F. In adults a more gradual rise occurs, and the pyrexia is of a more moderate character (100° F. to 101° F.). In a small proportion of cases of mild or well-localised inflammation no rise of temperature at all may be noted.

After an operation for the removal of the appendix the temperature usually falls rapidly, coincident possibly with some degree of post-operative shock, rises again in a small degree, and then gradually subsides, to become normal in a few days. Persistence of a raised temperature after operation usually indicates the development of some complication, the commonest of which is the presence of localised pockets of pus, as the result of inefficient drainage.

*Pulse.*—In the initial stages the pulse-rate rises in proportion to the pyrexia, and, in cases of only moderate severity, tends to fall with diminution of the temperature. In some cases, especially where peritonitis is present, there is a tendency for the pulse-rate to increase out of all proportion to the rise of temperature, or even with a fall of temperature. This sign, therefore, is a valuable indication as to whether the disease is progressing or passing into the quiescent stage. Where peritonitis is fully developed the pulse becomes increasingly small, rapid and "running," reaching 140 and even becoming uncountable.

*Abdominal distension.*—At first the abdomen may be hollow and retracted, but with progress of the disease, especially if associated with peritonitis, distension soon occurs owing to accumulation of gases which inflamed and paralysed intestines are unable to expel. In very severe cases distension is a very prominent sign.

*Swelling.*—A swelling may be felt in the right iliac fossa, and may vary from an ill-defined resistance to a large pointing abscess. Such a swelling usually denotes the presence of pus or peritonitis, but it may be due to mere paralytic distension of the cæcum associated with the inflamed appendix.

*Impaired resonance.*—This is an important sign in connexion with the presence of pus or exuded fluid. Its absence does not mean that there is no fluid, for if present in a small quantity it may be hidden entirely behind the distended cæcum.

*Constipation* is present in a number of cases. It is of two types—the one in which the constipation is a lifelong habit and the other in which the attack of appendicitis is preceded by several months of obstinate constipation. On account of this constipation it is frequently found that at the onset of an attack patients are given a large dose of a purgative with the idea that the pain is due to colic; this is a mistake, for it seems to cause an increase of inflammation and to break down protective adhesions which have formed. The correct treatment in the early stages is to put the patient to bed and to prohibit all solid food, and, if the bowels are loaded, to obtain relief by the action of enemata.

*Leucocytosis* is a valuable sign. It is found in the initial stage of the disease, and is marked in those cases in which suppuration is taking place. It will not reveal, however, whether the pus is inside or outside the appendix. It is not an infallible sign, for in some cases of virulent infection with general peritonitis and a low resistance of the patient an actual leucopenia is present. A falling temperature with a rising pulse and leucopenia is a bad prognostic sign.

After operation, the degree of leucocytosis is useful as an indication of the progress of the disease.

*Rarer signs.*—*Abnormal micturition* symptoms are occasionally met with,

generally taking the form of painful frequency associated with the onset of the attack. This is not necessarily due to any proximity of the inflamed appendix to the bladder, but occurs most often in those cases in which there is localised peritonitis.

*Sore throat*.—Occasionally the attack is preceded by the development of sore throat, and this has led some surgeons to attribute the cause of appendicitis to infection starting in the tonsils and pharynx.

*Diarrhœa* is frequently observed in children preceding the attack and continuing for several days. It may be caused by the emptying of products of decomposition from the appendix into the bowel, or the inflamed mucous membrane of the intestine may set up the appendicitis, œdematous mucous membrane of the appendix causing a blockage of the lumen.

*Discharge of mucus from the rectum*.—In rare instances, especially those in which the appendix is situated at the pelvic brim, an abscess may develop in the pelvis and by its size actually compress the rectum, which owing to the congestion of its mucous membrane discharges a large quantity of mucus. An inflamed and thickened appendix or the surrounding area of inflamed tissue may be made out by a rectal examination.

**Course of disease if left alone.**—The majority of cases of appendicitis get well of themselves; the inflammation subsides, and the patient is left with an appendix perhaps somewhat damaged, liable, and probably more liable than before, to further attacks, and with many or few adhesions round it, depending upon the severity of the peritonitis.

It is interesting to note that of 100 consecutive cases of appendicitis observed at St. Bartholomew's Hospital, in no less than 41 a definite history of previous attacks was obtained. Of these cases 18 gave a history of only one previous attack, 16 of two previous attacks, 4 gave a history of three former attacks, and 3 of four attacks. It cannot be said that any special severity was attributable to those cases in which the attack was the second in number (R. M. Vick).

If pus does form it may be absorbed, and it is clear to us now that the peritoneum can deal with a considerable amount of pus. If there is more than it can deal with, the pus may form a local abscess, which itself may be absorbed slowly, or may point and burst in many regions—for instance, into the bowel, the rectum, vagina, bladder, or, more rarely, on the surface of the skin. It may track to the left side of the abdomen and point in the left iliac fossa, or it may run up behind the cæcum and ascending colon to the under surface of the liver and give rise to a subphrenic abscess.

**Types of the disease.**—It is to be remembered that differences of the forms of appendicitis are of degree only, and not of kind, depending on the severity and extent of the inflammation. For purposes of diagnosis and treatment it is convenient to divide them into :—

A. Acute appendicitis.
   1. Catarrhal.
   2. With localised abscess.
   3. Gangrenous (without abscess or general peritonitis).
   4. With general peritonitis.

B. Recurrent, chronic or quiescent appendicitis (without complications).

## A. Acute Appendicitis.

1. **Catarrhal.**—By this is meant an inflammation which is limited to the interior of the appendix, and, though the signs of inflammation may be present

on the exterior, there is no visible pus or perforation. The attacks vary in severity from one sufficient to send the patient to bed for one or two days to an attack associated with vomiting, abdominal pain, tenderness and rigidity lasting five to six days. As the severity of the attack diminishes, all the signs and symptoms gradually subside.

2. **With localised abscess.**—In this case the signs and symptoms are more severe, and their continuance depends on whether the pus becomes shut off by adhesions or not. The appendix itself is thickened, stiff, and with congested veins on the peritoneal coat. There is often a point at the tip, middle or base, which shows a perforation. This may be due to, or is often associated with, an impacted fæcal concretion, which, by obstruction of the lumen, has given rise to retention of the contents, with subsequent decomposition, inflammation and ulceration. The perforation may become closed by the appendix gaining adhesions to a neighbouring coil of intestine or piece of omentum, so that the whole may become glued together and any further mischief prevented. More often, with the escape of a certain amount of fæcal material, a localised peritonitis is set up, and subsequently an abscess forms, which is prevented from spreading to the surrounding peritoneum by adhesive inflammation.

3. **With perforation or gangrene (without abscess or general peritonitis).**—In severe cases it is common for the inflammatory and ulcerative processes to cause perforation of the appendix at some spot, and in the most severe types a portion or the whole of the appendix may actually become gangrenous. In such a case the condition of the patient goes from bad to worse, the pulse-rate rises, vomiting is insistent, and the whole abdomen becomes tender and rigid. If the virulence of the infecting organisms is great, or the resistance of the patient low, limiting adhesions do not form and inflammation spreads rapidly over the whole surface of the peritoneum, resulting in :—

4. **With general peritonitis.**—This is the most severe type of the disease, and is a condition of exceeding gravity. The usual features that usher in an attack of appendicitis with general peritonitis do not differ essentially from those of an attack of a moderate degree of severity, but as a rule they are more severe and progressive, and the toxic symptoms are more pronounced. The facial expression alters greatly, becoming anxious-looking, and the features drawn and pinched. The abdomen is tense, tender and distended : vomiting is insistent, increasing, and occurs without retching (see *Acute Infective Peritonitis*, p. 884).

The signs of most value as indicating the gravity of the disease are a drop of the temperature to subnormal, a small, feeble and rapid pulse, and a low leucocyte count. If unrelieved, the patient dies within thirty-six or forty-eight hours of the onset of the disease or survives for several days, the final symptoms being those of septic poisoning and intestinal obstruction due to paralysis of the bowel.

*Post-mortem* blood cultures show that in almost all fatal cases infection of the blood-stream has occurred with the organism which was predominant in the local infection before death.

**Differential diagnosis.**—The four cardinal points to be borne in mind are :—

1. Sudden acute abdominal pain ;
2. Rigidity of the right side of the abdomen ;
3. Tenderness over the site of the appendix ; and
4. Vomiting associated with rise of temperature and pulse-rate.

While it is true that in a typical case there is very little difficulty in arriving at a correct diagnosis, there is a considerable number of other acute abdominal conditions which have similar clinical features.

*Colic.*—In intestinal colic the patient suffers from very acute abdominal pain, associated with vomiting and sweating, but the abdomen is neither rigid nor tender, the pain being rather relieved than otherwise by pressure.

*Perforated gastric or duodenal ulcer.*—In such an instance the onset of symptoms is more abrupt, and rigidity and tenderness are most marked in the upper part of the abdomen. Still, there are cases in which it is impossible to be quite certain until the abdomen has been opened.

*Colitis.*—This is usually a complaint of long standing; the onset is not acute, there is no abdominal rigidity, and the tenderness is over the course of the colon, which can be felt to contract under the hand.

*Disease of the gall-bladder* can usually be excluded by the taking of a careful history and a proper examination of the patient. The cases in which mistakes are made are usually those in which a distended and inflamed gall-bladder forms a swelling in the right iliac fossa.

*Inflammation of the ovary or Fallopian tubes.*—In cases of infection involving the ovary and tube a condition arises closely simulating appendicitis, for pelvic peritonitis results in the formation of a localised swelling and tenderness in the lower part of the abdomen associated with the signs of fever and vomiting. The symptoms, however, are generally not so severe as in appendicitis, vomiting is less insistent, and, seeing that the infection is most commonly bilateral, the abdomen is tender in both iliac regions: the site of the swelling is usually lower, and the most tender spot is just above the middle of Poupart's ligament instead of at McBurney's point; a vaginal examination often clears up the diagnosis.

*Ruptured tubal gestation.*—This is indicated by a sudden acute attack of abdominal pain with collapse, but in addition the patient will become blanched and show the other signs of loss of a large quantity of blood. There will also be usually a history of some irregularity or cessation of catamenia and a blood-stained vaginal discharge.

*Intestinal obstruction.*—The paralysis of the intestines and abdominal distension associated with vomiting in a case of acute peritonitis may often suggest the diagnosis of intestinal obstruction. The great difference between the two is that in intestinal obstruction the abdomen, though distended, is not tender or rigid; further, the leucocytosis commonly present in the suppurative process does not occur in intestinal obstruction uncomplicated by sepsis.

*Typhoid fever.*—The onset of this disease is much more protracted, and after a few days' illness a Widal's reaction will be present.

*Acute pneumonia and diaphragmatic pleurisy.*—Here the pain may be referred to the abdomen, and the abdominal muscles may become rigid, so that the diagnosis is very confusing in the event of physical signs not having developed in the chest.

Points to be noted are—that the respiration rate is usually greater than in appendicitis, the leucocytosis is considerably higher, and there is often a bluish coloration about the lips.

**Treatment.**—It is generally agreed that the removal of an inflamed appendix is the correct treatment, but it is not agreed as to the particular time at which an operation can be performed most safely. If one were assured that every case of appendicitis would terminate in recovery, and that the appendix could be removed in a quiescent stage, there is no doubt that this would be

the correct course. It is, however, impossible to say at the onset of the disease whether the attack will run a favourable course or whether the appendix will become perforated or gangrenous, leading to abscess formation or peritonitis. A certain proportion do not subside, and it is clear that if these are not operated on at once they will run a very considerable risk. Therefore the only safe rule to adopt is to recommend the removal of the appendix in every case in the early stages. An exception may perhaps be made in the case of a patient already in the second or third day of the disease in whom great distension of the intestines has occurred, and it is a moot point, which has to be decided in each individual case, as to whether the patient will run a greater risk by being left alone or operated on.

It is always advisable when possible to remove the appendix, but in the case of a large localised abscess a simple incision should be made into the abscess cavity and a drainage tube inserted without making at the time any further search for the appendix. After the abscess has healed it may be advisable to do a set operation for its removal, but it is commonly left, unless the patient is going to live in distant countries far from surgical aid, because in such cases the appendix often appears to shrivel or to have been entirely destroyed.

In cases of gangrene of the appendix or of general peritonitis there is no doubt that the correct course is an operation at the earliest possible moment. The inflamed appendix should be removed and all dependent parts of the peritoneal cavity drained. There is some difference of opinion as to whether the pus in the peritoneal cavity should be treated by means of irrigation with saline solution or by swabbing out the cavity with gauze strips. It would appear that the practice of swabbing out with gauze is attended with a higher mortality than that of irrigation, owing, probably, to small injuries to an already inflamed peritoneum.

*Serum and vaccine therapy.*—It is advisable in all cases when possible to obtain a correct diagnosis as to the infecting organism by making film preparations at the time of operation, and subsequently cultures. If the infection is due to streptococci, then anti-streptococcal serum may be administered, either subcutaneously, intravenously, or into the peritoneum. The common experience is that serum is not of any great value except in a very small number of cases; the condition of general peritonitis, however, is such a serious one that all available methods should be tried.

*Vaccine therapy.*—There is considerable difference of opinion as to whether autogenous vaccines are of any real service. It is certain, however, that improvement is noticeable in some cases, and this is quite sufficient to justify their use as an aid to treatment when the progress of the disease, in spite of an efficient operation, is not satisfactory.

**Post-operative complications.**—*Localised abscess.*—One of the commonest complications after the removal of an inflamed appendix is a persistence or recrudescence of the symptoms of fever, owing to the formation of loculi of pus between coils of intestine. Such an abscess is situated either in the region of the appendix, or more commonly in the pelvis, forming a swelling in Douglas's pouch and bulging into the vagina or rectum. In other cases the pus tracks upwards behind the cæcum and ascending colon to give rise to a subphrenic abscess.

*Fæcal fistula* occurs in about 3 per cent., and is not an uncommon sequel in cases in which the appendix or perhaps a portion of the cæcum was necrosed, or it may result from imperfect closure of the appendix, and it may perhaps in some cases act as a sort of safety-valve, when great distension of the bowel

follows on suppurative peritonitis. Such a fistula will as a rule close spontaneously, but if it continues to discharge fæcal material an operation will have to be performed for its closure, the abdomen being opened, the cæcum exposed, and the opening sutured.

*Intestinal obstruction* arises as the result of adhesions and fibrous bands formed between loops of intestine. In such a case the abdomen has to be opened, preferably in the middle line, and a free exposure made to find the obstructed loop.

*Venous thrombosis* either of the femoral vein or the superficial veins of the leg is apt to occur after suppurative appendicitis, and is regarded as being analogous to "white-leg" following an infection after parturition. A much more serious but rarer infection is that of the portal vein (*pylephlebitis*), which is attended with rigors, pyrexia, abdominal distension, vomiting, and later the usual features of septicæmia.

*Cystitis and pyelitis* occur in a small percentage of cases only, organisms gaining entrance into the bladder either through the blood-stream, or as the result of catheterisation subsequent on retention.

*Ventral hernia* is a complication which occurs owing to defective closure of the wound in which muscles or nerves are divided. It should be obviated firstly by opening the abdomen in such a way as to avoid this, and secondly by careful suture of the abdominal wall layer by layer. In some cases, owing to difficulty in exposing the appendix, it may be impossible to avoid cutting across the muscle, but a ventral hernia may still be prevented by careful suturing. If such a hernia does form, it is cured by excising the scar, opening the peritoneal cavity, dividing omental or other adhesions, dissecting out the different layers of the abdominal wall, and suturing them to each other. If for other reasons any operation is contra-indicated, the patient should be fitted with a suitable truss.

## B. Recurrent, Chronic or Quiescent Appendicitis (without Complications).

It is not at all uncommon to find patients who have recurring attacks of pain in the right iliac fossa accompanied with nausea, vomiting, and rise of temperature (see p. 985). The attacks vary enormously, both as regards frequency and severity. After the first attack such a patient may remain well for weeks, months, or even years, or the attacks may be so frequent as to prevent him from following his usual occupation.

The appearance of the appendix if removed from such a case differs greatly: there may be no adhesions, and very few changes may be visible to the naked eye, but microscopical examination shows thickening and fibrosis of the submucous and muscular coats and a round-celled infiltration of all the layers.

In other cases the mucous membrane of the appendix has become atrophied and replaced by granulation or cicatricial tissue, so completely as to amount to a practical obliteration of the appendix or a localised stricture. Such a partial obliteration, if occurring in the length of the organ, causes the distal portion to be distended into a cyst containing jelly-like mucus or sero-purulent fluid. In other cases a diverticulum is formed by protrusion of the mucous membrane, through a defect in the muscular coat.

In other cases again, as the result of repeated attacks, the appendix is found firmly bound to the cæcum or buried in adhesions, so that it is only with considerable difficulty that it can be found and removed; or it is attached by adhesions to the ovary, rectum, bladder, parietal peritoneum,

or more distant organs. It is never possible to say whether an operation for its removal will be very easy or very difficult. Though the diagnosis may be quite easy when the patient has been under observation during a typical attack, during the quiescent period the symptoms recorded are often difficult to interpret. There are many sources of abdominal pain, such as colitis, colic, chronic gastric or duodenal ulcer, which may be mistaken for it; other causes are renal calculus, movable kidney and disease of the ovary and Fallopian tube.

**Chronic appendicitis associated with septic changes.**—It has been mentioned above that suppurative appendicitis may be followed by septic phlebitis, and it seems to be becoming clear that chronic recurrent appendicitis may be associated with septic changes elsewhere, such as a mild form of septic arthritis or septic choroiditis, and in fact any infective process. The theory is that small doses of organisms, freed from the appendix, gain entrance to the blood-stream and like those derived from septic gums are liable to give rise to chronic septic processes in many parts of the body.

*Treatment.*—One attack of appendicitis does not give immunity against future attacks—in fact, it seems to increase the liability. Therefore the treatment advised is the removal of an appendix after the first attack, as it is impossible to say whether a second will be slight or grave, and as an operation in the quiescent stage can be done with the very least risk. Surgeons vary as to the incision they prefer in such an instance. Some adopt the gridiron incision, that is, a splitting operation through the oblique abdominal muscles over the appendix, but the one that is generally preferred is an incision through the linea semilunaris, the sheath of the rectus being opened, that muscle retracted towards the middle line, and the abdomen opened through the posterior sheath. This incision obviates the necessity of cutting any muscles or nerves and leaves the patient with a strong abdominal wall.

**Prognosis in appendicitis.**—The following figures are taken from patients who were operated on at St. Bartholomew's Hospital during the year 1912, and indicate the high degree of mortality in patients with suppurative appendicitis:—

| | |
|---|---|
| Mortality of patients with appendicitis, acute gangrenous or perforated | 19·3 per cent. |
| Mortality of patients with appendicitis, acute, with suppuration | 21·2 „ |
| Mortality of patients with appendicitis, acute, without suppuration | 2·3 „ |
| Mortality of patients with appendicitis, subacute, quiescent or chronic, without suppuration | ·6 „ |

## Tuberculosis of the Appendix.

This is usually associated, though not invariably, with tuberculosis of the mesenteric glands, cæcum, and surrounding peritoneum. Often the condition gives rise to no acute symptoms, though if it does these are similar to those of ordinary appendicitis. Usually the attacks are mild, and on palpation only an ill-defined lump is felt, and the fever is not great.

The *treatment* consists in the removal of the appendix and of any tuberculous glands in the neighbourhood. Should an abscess form, it has to be opened in the usual way, but a sinus of long duration is liable to follow.

### Actinomycosis of the Appendix

Is very rare, and when it occurs an abscess usually forms in which the characteristic granules of the fungus are recognisable in the pus.

### Primary Malignant Disease of the Appendix.

Primary malignant disease of the appendix is a rare condition, though not so rare as at first imagined, and is usually only discovered accidentally when examining the organ after removal. It is generally of the columnar-celled carcinomatous variety and situated in the middle part of the appendix. Endotheliomata also occur. If the condition is recognised at the time of operation a wider removal than usual is advisable, though if identified only on microscopical examination it is not necessary to perform a second operation, because most of the recorded cases seem to have done well.

# Section XXV.

## SURGERY OF THE RECTUM AND ANAL CANAL.

### Surgical Anatomy.

**The Rectum.**—The anatomical description of the rectum has from time to time undergone changes. Prior to 1885, when Treves delivered his Hunterian lectures on the anatomy of the intestinal canal, the rectum was considered to begin at the sacro-iliac synchondrosis. Since that date anatomists have styled the old first part of the rectum the pelvic colon, and the rectum now commences, where the old first portion ended, opposite the body of the third sacral vertebra, and ends by joining the anal canal one inch beyond the tip of the coccyx, after a course of four to five inches.

A knowledge of the main points in the development of the rectum and anal canal is essential to a proper appreciation of their malformations and will materially assist the student in the study of the diseases which involve this portion of the intestine.

The work of Keith and Wood Jones on the malformations and development of the rectum has enabled us on morphological grounds to subdivide further the rectum into two parts : (1) *pelvic portion ;* (2) *perineal portion.*

The *pelvic portion* commences where the pelvic meso-colon terminates, opposite the body of the third sacral vertebra. At this point the peritoneum covers the gut in front and laterally and gradually leaves the sides until at the termination of the pelvic portion it is reflected off the rectum on to the bladder in the male and posterior fornix in the female. At the same level the appendices epiploicæ come to an end and the three longitudinal muscular bands blend to form a continuous coat. The anatomical features of this portion of the rectum are thus well marked externally. Internally the upper limit is fixed by the upper " valve of Houston," which is a prominent fold encircling the bowel and projecting into the lumen as a ledge, especially well marked on the right side. The lower limit is equally well defined by the lower " valve of Houston," which is more prominent on the left side. This lower limit represents the termination of the original hind gut and the circular muscle is thickened at this point (the third, or Nélaton's sphincter). It is at this point that the rectum ends in cases of atresia recti (*vide infra*).

The *perineal portion* of the rectum (or rectal ampulla) lies below the pelvic cavity, and is that portion which is developed when the hind gut ceases to open into the cloaca, in order to establish communication with the proctodæum. It is this portion which fails to develop in atresia recti. It is devoid of a peritoneal covering and terminates at the internal sphincter (the thickened termination of the circular muscle), where the anal canal commences.

**The anal canal** (or *proctodæum*), unlike the rectum, which is developed

from endoderm, has its origin from ectoderm. It is embraced by the external sphincter and a portion of the levator ani. Owing to the action of the latter muscle the walls are compressed laterally in contrast to those of the rectum, which collapse antero-posteriorly.

The lining membrane of the anal canal is not a true mucous lining, but in reality modified skin, a fact which has an important bearing on the diseases of the anal canal (fissure ulcer, fistula, etc.). The upper limit of the anal canal can be recognised by the remains of the original septum between the proctodæum and the rectum.

These remnants, known as Morgagni's valves, resemble diminutive semilunar aortic valves. Their free borders have a dentate appearance (the pecten), and the papillæ so formed have been described as the sense organs of the rectum. When hypertrophied these papillæ are often responsible for rectal pain and anal irritation.

Between these valves the lower end of the rectum above the anal canal is puckered into folds (Morgagni's columns) by the internal sphincter, and in these folds run the terminal superior hæmorrhoidal vessels. It is here that internal hæmorrhoids have their origin.

The anal canal terminates at the white line where the skin of the perineum joins the anal membrane and is encircled by the external sphincter. The external sphincter arises from either side of the coccyx, and its fibres meet in front of the anus in the central point of the perineum. Some of the superficial fibres decussate and are inserted into the skin. The deeper fibres blend with some of the levator ani fibres as they meet behind the upper end of the anal canal.

*Nerve supply.*—The nerve supply of the rectum and anus is derived from the sympathetic system and from the spinal cord at about the level of the first lumbar vertebra, through the second, third and fourth sacral nerves. The inferior hæmorrhoidal branch of the internal pudic supplies the skin of the anus. The spinal cord centre is at the same level as the genito-urinary ; the cerebral connexion is not yet known.

*Blood supply.*—The two terminal branches of the superior hæmorrhoidal artery, after passing along the sides of the rectum at the line of peritoneal reflection, bifurcate and reach the submucous tissue by passing through the muscular coat at the junction of the pelvic and perineal portions. The branches continue to run straight downwards, giving off lateral branches which anastomose with one another and to some extent with the terminal branches of the inferior hæmorrhoidal artery in the neighbourhood of the external sphincter. The terminal branches of the superior hæmorrhoidal artery, when hæmorrhoids are present, can be felt pulsating beneath the mucous membrane. With these longitudinal arteries run the superior hæmorrhoidal veins which commence in the submucous connective tissue as sinuses about the size of a grain of wheat. These sinuses form the superior hæmorrhoidal plexus, from which veins run up with the arteries obliquely through the muscular coat into the inferior mesenteric, and so into the portal vein. These veins are without valves. In young people under normal conditions the superior hæmorrhoidal plexus has only small communications with the inferior hæmorrhoidal plexus. This latter plexus lies under the skin around the anus. The plexus empties into the inferior hæmorrhoidal veins, and so into the vena cava. In later life, and when piles arise, there is a free communication between the superior and the inferior hæmorrhoidal plexuses. The middle hæmorrhoidal vessels play only a small part in the supply of the rectum, and Hamilton Drummond's experimental

injections show that for the most part there is little anastomosis between the middle and superior hæmorrhoidal vessels.

*Lymphatics.*—See p. 337.

## Congenital Malformation of the Anus.

The endoderm forms at the hinder end of the fœtus the endodermal cloaca, into which open the genital, urinary, and intestinal canals. In the course of development the endodermal cloaca develops into the genital organs, bladder, and urethra, whilst the opening of the rectum is shifted downwards and backwards towards the perineum where it comes to meet a short involution of epiderm, the proctodæum (Keith). Maldevelopment in connexion with the endodermal cloaca results in the deformities which will be referred to under *Extroversion of the Bladder, Epispadias, and Hypospadias;* an arrest in the descent of the anal orifice of the cloaca towards the perineum gives rise to :—

**Imperforate anus.**—1. If the post-allantoic gut fails to develop from the

Fig. 399.—Anus absent. Rectum terminating in blind pouch.

Fig. 400.—Anus ending in *cul de sac.* Rectum ending in blind pouch, with some, but not much, tissue between it and *cul de sac.*

hind gut the rectum may terminate blindly at, or below, the reflection of the peritoneum, and the result is known as *imperforate rectum* or *atresia recti.*

2. If the hind gut fails to separate completely from the cloaca, the rectum may terminate in the prostatic urethra (in the male) (Fig. 401), in the vagina or vulva (in the female) (Fig. 402). The malformation is then known as *urethral anus* or *vulvar anus* (aberrant anus).

3. If the rectum is fully developed while the anal canal fails to develop, or remains separated from the rectum by a septum, the condition is known as *imperforate anus* or *atresia ani* (Figs. 399 and 400).

4. If the development of both rectum and anal canal is arrested the condition is known as *atresia ani et recti.*

*Treatment.*—1. *Of atresia ani.*—If the anus is imperforate, intestinal obstruction will occur soon after birth, and the condition requires immediate operation.

If the rectum is separated from the anus by a thin septum only (Fig. 400), the condition can be easily remedied by incision.

2. *Of atresia recti.*—If the development of the rectum has been arrested, whether the anal canal is present or not, the surgeon is faced with a very difficult operation to find the blind end from the perineum, and it will often be necessary in the end to open the abdomen and perform colostomy. Under these circumstances the chances of recovery are small.

If the abdomen is opened in the first instance the chances are better, though the prognosis is bad. The anatomical condition is often far less favourable than it appears in Figs. 399 and 400.

3. *Of aberrant anus.*—In the case of a urethral anus an early attempt should be made to separate the rectum and urethra by perineal dissection. When a vulvar anus exists, operation may be delayed until puberty approaches.

## Methods of Examination.

Male patients should be examined in the genu-pectoral and females in the left lateral position. For all operations and examinations under an anæsthetic the lithotomy position is best.

*Digital examination.*—The examination of the anus should always be bidigital, and of the rectum "bimanual." In the latter case conditions outside the rectum producing rectal symptoms may be discovered, and in carcinoma of the rectum the degree of infiltration, mobility, etc. In the

FIG. 401.—Anus ending in a *cul de sac*. Rectum opening into prostatic urethra.

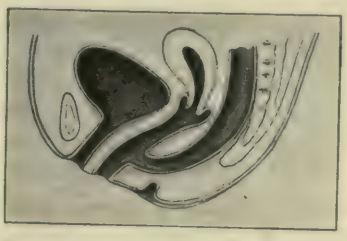


FIG. 402.—Rectum opening into vagina, usually just above the posterior fourchette.

former case, with the anal canal between index finger and thumb, much may be learnt which cannot be ascertained with one finger.

The student is here warned of the risk he may run with the bare finger should syphilitic condylomata be present round the anus.

The use of a speculum is invaluable, and no certain diagnosis of hæmorrhoids can be made without one, unless they protrude from the anus. A tubular speculum, *e.g.*, Kelly's, is the best for this purpose.

A sigmoidoscope must always be used when carcinoma is suspected and cannot be felt with the finger. It is essential for the bowel to be empty and at rest, but an anæsthetic is not necessary. The pelvis must always be raised, the patient lying semi-prone. The instrument must be well lubricated and passed *by sight* only.

The inflator should only be used to keep the lumen patent as the instrument advances, *i.e.*, to provide a small cushion of air to assist advance, and the rectum should never be distended with air.

A sigmoidoscope with a magnifying lens (*e.g.*, Wolf's) is the most useful pattern.

Prior to an examination attention should be paid to the following points in the history of the case :—

1. The number of actions of the bowels in the twenty-four hours and the character of the motions.

2. The passage of blood, mucus, or pus in the motions or at other times.

3. Whether anything is protruded from the anus during an action.
4. Whether there is pain during defæcation or after or between times.
5. Whether there is loss of weight or other constitutional disturbance.

### Foreign Bodies in the Rectum.

Foreign bodies of the most varied kind have at times been introduced into the rectum. Many instances are on record of thieves who have used the rectum for stolen goods; convicts have been known to secrete tools to aid their escape; inmates of asylums and others of weak intellect have met disaster by the purposeless insertion of bottles and the like.

More often foreign bodies are introduced to relieve anal irritation, and in the museum of St. Bartholomew's there is a blacking bottle which was inserted base downwards for this purpose and was only removed by a combined abdominal and perineal operation. The patient succumbed to peritonitis due to sloughing of the rectum.

Foreign bodies which have been swallowed and fail to pass the sphincter ani are sometimes responsible for ischio-rectal abscess and fistula-in-ano, *e.g.*, fish-bones, pins, splinters of wood, etc., though the popular idea that fistulæ are due to foreign bodies is only occasionally correct.

Hard scybalous masses resulting from prolonged constipation may accumulate in the rectum to such an extent as to cause intestinal obstruction. Similarly bismuth which has been taken in large quantities for radiography has been known to act as a foreign body in the rectum and to be equally difficult to dislodge.

### Injuries of the Rectum.

Apart from those due to foreign bodies which have been swallowed or introduced *per anum*, injuries may result from falls upon a sharp-pointed object or follow the incautious use of a bougie or the sigmoidoscope.

During parturition rupture of the perineum may involve the rectum, and severe fractures of the pelvis may be complicated by a tear of the rectum. A very careful examination under an anæsthetic must be made to ascertain if the peritoneal cavity has been penetrated, and if this is found to be the case laparotomy is urgent.

If the rectal wall is extensively lacerated, whether extra- or intra-peritoneally, it is advisable to perform colostomy. Pelvic cellulitis, apart from peritonitis, is a great danger, and free drainage must be secured, followed by frequent irrigation, either by enlarging an existing wound, if one exists outside the rectum, or by stretching the sphincter and inserting a tube when the injury is confined to the rectal walls. The possibility of associated injury to bladder, vagina, etc., must be kept in mind.

### Hæmorrhoids or Piles.

It is customary to divide hæmorrhoids into an internal and external variety. The two varieties should, however, be regarded as independent conditions from a clinical point of view.

**External hæmorrhoids** occur as soft, globular, pinkish-blue swellings beneath the skin around the anus, and are due to a varicosity of the inferior hæmorrhoidal veins. They become more prominent when the patient strains. They are common in people of sedentary and alcoholic habits, the subjects of chronic constipation, and rarely give rise to much discomfort other than a feeling of fulness about the anus and itching. Occasionally an external pile becomes thrombosed, owing either to a prolonged spell of constipation

or to hæmorrhage during an effort of straining. Then the pile gives extreme discomfort, and may become acutely inflamed and extremely painful.

*Treatment.*—Whenever a painful thrombus occurs in an external skin tag, the pile should be incised under local anæsthesia, the clot turned out, and the remains of the pile cut off. When inflammation is severe, hot carbolic fomentations (1 in 100) give great relief; when less severe, lead and opium lotion will often relieve the pain. The patient should be instructed to observe scrupulous anal cleanliness and to avoid constipation. Recurrences are common, and, when thrombotic external piles have once given trouble, it is advisable to cut them off under local anæsthesia.

**Internal hæmorrhoids (piles proper).**—Each pile consists of a bunch of varicose veins around one of the terminal branches of the superior hæmorrhoidal artery, originating beneath the mucous membrane of the lower end of the rectum, and extending downwards beneath the lining of the anal canal, where communications are established with the inferior hæmorrhoidal veins. The amount of connective tissue in the pile varies with the age of the pile and the amount of inflammation to which it has been subject. Three main hæmorrhoids are commonly met with, but often smaller piles intervene, increasing the number to six or seven.

*Etiology.*—The absence of valves in the superior hæmorrhoidal veins, combined with the upright position, predisposes to piles when, from any cause, congestion occurs. Of the innumerable causes for congestion the most important is constipation, especially when aggravated by a sedentary occupation.

Congestion due to disease of the liver, to pressure within the pelvis (*e.g.*, pregnant uterus, malignant disease of pelvic viscera), or to malignant disease of the rectum itself must always be considered.

*Signs and symptoms.*—In the early stages a pile does not protrude from the anus, but later on it will do so during defæcation, returning spontaneously after the act. In the later stages the piles remain protruded, and can only be returned with difficulty, if at all.

In addition to the above, the most important symptoms are pain, hæmorrhage, and discharge of mucus. Pain is seldom severe in uncomplicated cases, unless the piles are protruded or strangulated and ulcerated, though a dull aching pain in the lumbo-sacral region, which is relieved by lying down, is a common symptom. Hæmorrhage is seldom an important feature when the piles are not prolapsed, in most cases amounting only to a few streaks of blood during the passage of a hard motion. When piles are prolapsed, hæmorrhage is often of a persistent and serious character. When the venous return is impaired by constriction of the neck of the piles, blood may escape in a steady ooze or bright arterial blood may spurt in jets from a single abrasion. In this way the patient may lose a considerable quantity of blood each time the bowels are moved and, in consequence, become pale and weak from the loss. Discharge of mucus is not great unless there is prolapse or ulceration.

In some cases, as the result of constriction and impairment of venous return, a pile may become *inflamed* and *infected*, so that it becomes a seat of phlebitis. According to the degree of strangulation and infection, the condition may improve spontaneously or result in thrombosis, ulceration, or even sloughing and gangrene of the pile, and sometimes septic infection may spread to the general circulation.

Occasionally thrombosis is followed by fibrosis, and a fibrous polyp results which, in process of time, becomes pedunculated and may prolapse through the anus.

*Diagnosis.*—This should be made by inspection, digital examination, and the use of a speculum.

When a digital examination is made the anal canal should be palpated between the index finger within and the thumb outside. In this way redundancy and thickening of the mucous membrane and abnormalities can be detected. An accurate diagnosis can only be made by inspection through a speculum, and the best for the purpose is Kelly's. As the speculum is withdrawn, the hæmorrhoids protrude into the lumen. The greatest care is necessary, especially in those past middle life, to exclude carcinoma of the rectum and other extrinsic causes for congestion.

*Treatment* may be palliative or operative.

**Palliative treatment** consists in employing such means as are calculated to relieve congestion of the hæmorrhoidal veins by preventing constipation, by correcting excessive tendencies in eating and drinking, and by avoiding sedentary occupations.

Locally, when the piles either prolapse or cause pain on defæcation, cotton wool should be employed in *lieu* of toilet paper. Congestion may be relieved and hæmorrhage diminished by ointment introduced from a collapsible tube through a detachable nozzle, or by suppositories. Hamamelis and tannic acid, separately or combined, are the most useful bases for either suppository or ointment. Ichthyol, iron, bismuth, calomel, and many other drugs are employed for the same purpose.

During an acute attack opium and belladonna may be added to the suppository or ointment, and considerable relief from the sense of swelling and tension in the rectum may be produced by an injection of ʒi of tincture of hamamelis in 4 ounces of cold water night and morning.

In this way the symptoms which hæmorrhoids produce may be relieved or prevented if the piles have not reached a stage in which prolapse is frequent. Palliative measures are essential when piles are complicated by cirrhosis of the liver, pregnancy, etc. In these circumstances an operation should only be employed when symptoms are too severe to be relieved by palliative measures.

**Operative treatment.**—Though internal hæmorrhoids can often be relieved by treatment as above, they can only be cured by operation.

The following methods may be employed :—(1) Ligature ; (2) clamp and cautery ; (3) excision of the pile-bearing area (Whitehead's operation).

*The operation of ligature* is the operation of choice for the great majority of cases. It is a straightforward operation presenting no difficulties, and from which uniformly good results may be expected, with a cure in from twelve to fourteen days. With ordinary precautions, complications, such as recurrent or secondary hæmorrhage, ulceration, and stricture, seldom occur, and, in the absence of any constitutional disease which predisposes to hæmorrhoids, recurrences are rare.

*Clamp and cautery*, carefully employed, is an admirable operation which is suitable for cases of not more than three piles, especially when the skin is not involved in the piles. It is very suitable for gangrenous cases, when it is advisable to avoid a cutting operation owing to the risk of spreading sepsis. Recovery is rapid (ten to twelve days), and pain after operation tends to be less than after either ligature or a Whitehead operation.

*Whitehead's operation* has the merit of being thorough, but it is a difficult operation in inexperienced hands and requires greater care in the after-treatment to secure a good result than either ligature or clamp and cautery, and the patient is laid up for a longer period (three to four weeks). If sepsis

occurs, considerable care is required to avoid anal stricture, and convalescence is greatly prolonged. For mild and moderately severe cases it presents no advantages over ligature or clamp and cautery, and delays convalescence unnecessarily. For cases presenting a continuous ring of hæmorrhoids, and especially for those associated with pruritus ani or prolapsus ani, it has advantages in experienced hands.

*Carbolic acid injections.*—When it is not possible for a patient to lie up for an operation, or for some reason an operation is contra-indicated, and when not more than two or three prominent piles are causing trouble, relief may be obtained by injecting 3 minims of a 20 per cent. solution of carbolic acid in equal parts of glycerine and water into each pile, one at a time, on separate occasions.

The operation of ligature will alone be described.

*The operation of ligature.*—Careful preparation to ensure an empty rectum is essential. It is not necessary to stretch the sphincters unless they are much hypertrophied. Each pile should be secured in a pair of pressure forceps, after gentle dilatation of the anus. The index finger of the left hand is then held against the external sphincter while the pile is cut away, together with a V-shaped wedge of redundant skin from the anal margin, thus exposing the sphincter and the submucous layer. The pile is then stripped up to its base, firmly tied with No. 8 plaited silk, and removed, leaving sufficient frill to hold the ligature securely. The ends of each ligature are left projecting from the anus. Redundant tags of skin at the anal margin, together with any external thrombi, are removed, and half an ounce of vaseline is injected from a collapsible tube into the rectum. A small rubber drain is inserted to allow flatus to pass and to control oozing.

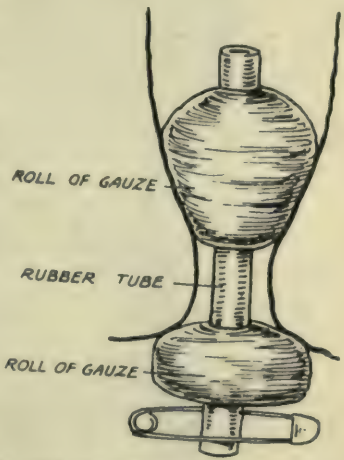



FIG. 403.—To illustrate the method of plugging the rectum for the arrest of hæmorrhage. (After Lockhart Mummery.)

*After-treatment.*—The tube should be removed at the end of twenty-four hours, and on the evening of the third day 4 ounces of warm olive oil are injected into the rectum, followed by an ounce of castor oil by the mouth in the early morning. The ligatures usually separate about the tenth day, when the patient may be allowed up. On the twelfth to fourteenth day the patient is usually fit to be discharged.

If recurrent hæmorrhage occurs, dry wool should be packed in between the tube and anus, and if this is unsuccessful exposure under an anæsthetic is necessary to secure the bleeding point. A considerable amount of blood may be lost in a short time while bleeding is taking place into the bowel as well as outside. A successful method of controlling hæmorrhage has been employed by Mummery (Fig. 403). A strip of gauze is firmly wrapped and secured round the end of a piece of drainage tubing and passed into the rectum through a speculum. The tube is then pulled upon so that the gauze is firmly pressed against the bleeding area. This plug is kept in position by packing gauze round the portion of the tube exposed outside the anus. The external plug is kept in position by a safety-pin passed through the tube.

Secondary hæmorrhage is rare, but may occur during the second week. Hot hazeline injections, followed by packing round a vulcanite plug, may first be tried, but usually it is necessary to secure the bleeding vessel under an anæsthetic, and if this fails the rectum must be plugged as described above.

After the first action of the bowels a daily bath may be taken, and the wound area should be kept clean with peroxide or perchloride swabs. Œdematous skin tags usually shrink up during the second week; shrinkage is accelerated by the use of lead lotion. Tags that remain after twelve days should be cut off.

## Prolapse of the Rectum.

Prolapse is most often met with at the extremes of life—in children before the curve in the sacrum has developed to accommodate the rectum, and in

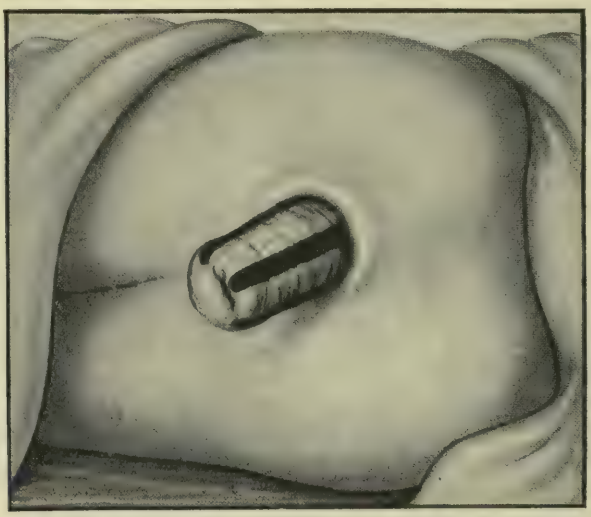


FIG. 404.—Treatment of prolapse of the rectum by the cautery. The black lines of cauterisation on the protruded bowel are seen.

old people when the muscles of the pelvic floor have lost their tone. Adults, however, more especially women, are not exempt.

In children prolapse is due to straining at stool aggravated by direct irritation from threadworms, rectal polypus, or diarrhœa, or by reflex irritation from phimosis, stone in bladder, etc. Children of the better class, who are well fed and well looked after, seldom suffer from this complaint.

In later life debility from any cause resulting in loss of muscular tone and wasting may predispose to prolapse if straining occurs during defæcation.

Residents in hot climates are more prone to suffer than others.

Prolapse always commences with protrusion of the mucous membrane (*prolapsus ani*). Later the rectal wall is dragged on and the prolapse becomes complete (*procidentia recti*). When the membrane covering the prolapse is continuous with the anal margin (*i.e.*, without a sulcus) the prolapse is one of the *first degree*. When, however, the prolapse commences above the anal canal and a sulcus is formed between the prolapse and the anal canal, it is known as a prolapse of the *second degree*.

If a prolapse occurs suddenly before the sphincter has become dilated and

patulous by frequent stretching, strangulation of the protruded portion may occur (if it is not reduced), and this may be followed by gangrene and sloughing. In chronic cases, when the bowel is constantly protruded, the sphincter loses all tone and the exposed bowel becomes ulcerated from congestion and constant friction.

*Symptoms.*—In the early stages the prolapse only comes down on defæcation and returns spontaneously. Later on the bowel is liable to come down on slight provocation, such as coughing, and it becomes necessary to replace it on each occasion.

Dull aching pain and a mucous and occasionally blood-stained discharge are constant symptoms.

*Treatment.—In children.*—The first essential is to obviate all cause for straining by removing sources of irritation and keeping the bowels regular and the motions soft.

When the bowel is protruded it must be well lubricated and replaced with the child in a recumbent position, a pad applied, and the nates strapped together. If the bowel is inflamed and congested, it should be sponged for some time with cold water and, after an interval, gently squeezed until it can be replaced. The child should be taught to use the bed-pan lying on the back until the condition is cured. Operative treatment is seldom necessary, but in difficult cases it is often wise to give an anæsthetic and gently stretch the sphincter to secure replacement. If recurrence is frequent, the cautery is required (*vide infra*).

*In adults.*—Palliative measures in the absence of such a direct cause as a polypus seldom cure complete prolapse.

**Operative treatment.**—Application of the actual cautery to the mucous membrane by setting up inflammation in the submucous tissue will produce adhesions between mucous and muscular coats. The entire prolapsed portion must be drawn down as far as possible, cauterised longitudinally in four lines, and then replaced (Fig. 404). The patient must be kept recumbent for three weeks and the bowels opened by enemas. This method is often successful in slight cases which are not of long standing.

Severe cases must be treated by open operation, and many operations have been devised for the purpose.

*Amputation of the prolapse*, when complete, involves opening the peritoneal cavity under conditions which preclude asepsis, and is not recommended.

*Colopexy*, or fixation of the pelvic colon to the iliac fossa or the abdominal wall, is sometimes, but not often, successful.

*Rectopexy*, as devised by Mummery, is a more rational and more successful operation. The method in brief consists in opening up the retro-rectal space by a transverse incision across the ano-coccygeal ligament and packing this space with strips of gauze, which are left in for about a week and then gradually withdrawn. The object is to secure healing by granulation, and so produce firm adhesions between the rectum and the sacrum.

No operation has yet been devised that will cure all or even the majority of cases.

Operation will seldom succeed in old people, and should not be advised. The cautery may be tried, but a truss will have to be worn.

## Anal Fissure.

A fissure consists of a longitudinal tear in the lining membrane of the anal canal (Fig. 405). It is usually met with at the posterior margin

of the anus, though occasionally it occurs at the anterior commissure, and then in women more often than men. Lateral fissures are very rare. At the lower extremity of the fissure there is usually a small tag of œdematous skin, which is known as the " sentinel pile."

A fissure is traumatic in origin and results from undue stretching of the anus by hard fæces or by some foreign body. This tear often starts at one of the valves of Morgagni, which by projecting into the lumen at the upper limit of the sphincter are exposed to injury. As Mummery has pointed out, the posterior commissure of the anal membrane has the least support from circular muscle fibres, owing to the origin of the sphincter from the coccyx in two lateral halves. Consequently, if the anus is stretched, the lining gives way at this point. This can easily be demonstrated by undue forcible stretching. In women, owing to the fibres decussating to blend with the sphincter vaginæ, there is deficient circular support also anteriorly.

FIG. 405.—The rectum and anal canal laid open to show an anal fissure. (After Wallis.)

*Symptoms.*—The characteristic feature of a fissure is *sharp, excruciating pain coming on immediately after defæcation* and persisting for varying periods, often for as long as an hour or more, and then gradually subsiding. Occasionally the pain does not come on immediately after an action, but may be delayed for as long as half an hour. Involuntary spasm of the sphincter may seriously disturb sleep. Many patients are incapacitated from following their employment owing to the pain. Patients will often delay an action of the bowels as long as possible, and thus aggravate the complaint by constipation. When a fissure has become chronic and its base indurated, pain after defæcation may be comparatively slight.

Not infrequently a fissure gives rise to pruritus ani, and hæmorrhoids are often found to complicate the condition. When neglected it may often become the starting point of a peri-anal abscess and consequent fistula.

*Treatment.—Palliative measures* to ensure the daily passage of a soft motion and a sedative ointment (*e.g.*, bismuth and cocaine) applied before and after an action, coupled with careful cleansing of the part, may be sufficient to cure slight and early cases.

*Operative measures.*—In most cases an operation is necessary to put the sphincter at rest in order to get the fissure to heal. An incision is made through the base of the fissure dividing the superficial muscular fibres, and the incision is extended outwards for about an inch beyond the skin margin. The lateral margins are then excised so that a lozenge-shaped wound is produced. This is lightly packed with wool and dressed daily. In about ten days to a fortnight healing should be complete. The operation can be per-

formed under local anæsthesia, but healing will be considerably delayed if the patient is not confined to bed afterwards.

## Pruritus Ani.

Anal irritation may be a symptom of any rectal complaint and cease with the cure of the complaint (*e.g.*, threadworms). The term pruritus ani, however, denotes a condition of *intense anal itching, which is usually associated with dermatitis of the anal margin.* In the initial stage the condition of the skin appears normal. Later, as the result of scratching and chronic inflammation, the anal folds of skin become thickened, pearly white, shiny, and sodden. This is known as the second stage, and the condition may be compared to a "washerwoman's hand." In the most advanced condition the skin loses its elasticity from fibrosis, radiating cracks and abrasions form between the folds, and actual ulceration occurs (third stage). In a certain number of cases patients may complain of intense anal irritation which has existed for a long time and yet show only slight signs of dermatitis.

*Causation.*—Although in a small percentage of the cases no cause can be ascertained for the irritation, in the great majority it will be found that the dermatitis is dependent on an anal discharge which gives rise to an infective condition of the anal margin. The important factors in the production of this dermatitis are the constant presence of organisms, warmth, and moisture in the folds of skin in a region richly supplied with nerves, where abrasions from injury or scratching are liable to occur. Consequently want of cleanliness in the anal region is largely responsible for the onset of the complaint.

Careful examination of the anal canal will usually reveal some definite primary cause for this discharge. *A small ulcer at the ano-rectal junction or a submucous fistula* in this situation are easily overlooked, and there is no doubt that they are responsible for many cases of supposed idiopathic pruritus.

In some people the presence of prolapsing piles, a polypus, a fissure, or a discharge from the vulva are factors in the onset.

In other instances extroversion of the mucous membrane after Whitehead's operation keeps the anus constantly moist and is the exciting cause. Slight prolapse of the mucosa acts in the same way.

A not uncommon cause, and one not generally recognised, is *hypertrophy of the papillæ of Morgagni.* These sensitive papillæ (*vide* p. 995) are often very prominent and project into the lumen of the canal as nipple-like processes. As many as five or six are sometimes seen, and the larger ones may be a quarter of an inch long. When pruritus exists and these papillæ are obviously hypertrophied a cure may often be effected by destroying them with the cautery. Before the cautery is used they should be dusted with anæsthesin powder or swabbed with a 10 per cent. solution of novocaine. More than one application is usually required.

Although in the majority of cases a local cause can be discovered to explain pruritus, there still remain some in which the condition appears to be constitutional. In this class a family history of pruritus is often obtained, and these patients will often state that excessive smoking or definite articles of diet provoke the condition, *e.g.*, shell-fish, coffee, champagne, strawberries, etc.

Pruritus is often a symptom in gout, diabetes, general eczema, oxaluria, etc., and it is probable that the diet and mode of life which provokes "the disease" is also responsible for the pruritus.

*Clinical course.*—Pruritus ani, commencing as a symptom, becomes a disease when dermatitis is established. The persistence of this trouble may indeed wreck a patient's life owing to loss of sleep, irritability of temper, dyspepsia, and loss of appetite. Some, indeed, reach such a state of nervous prostration as to render themselves totally incapacitated for all work.

*Treatment.*—The treatment of pruritus has two main essentials: (1) To find a local cause and remove it; (2) to treat and cure the dermatitis. Indiscretions in diet and mode of life must also be corrected.

1. *Local causes.*—A consideration of the structure and development of the anal canal makes it clear that it is very liable to abrasions and consequent inflammation.

On the one hand, the lining of the canal is neither true mucous membrane nor true skin, and as such is more vulnerable when the sphincter contracts over hard fæces or foreign bodies; and on the other hand, the valves at the line of fusion between rectum and anal canal, by virtue of their position immediately above the closed anus, invite injury, and the crypts above them provide suitable pockets for local sepsis.

When a small ulcer (or a submucous pocket) is found at the ano-rectal junction it should be treated with the electric cautery or with pure lactic acid. Hypertrophied papillæ should also be destroyed with the cautery. If there is a marked spasm of the sphincter it should be stretched. Stretching of the sphincter alone often gives great relief in pruritus. Hæmorrhoids and fissure and every possible cause within the rectum must be dealt with.

2. *The dermatitis.*—(*a*) Of the first stage. It is of the utmost importance that the patient should realise the necessity of *keeping the anus clean and dry* and *avoiding constipation*. After each action the bowel should be washed out with a little warm water. This serves to clear the rectum, and so to keep the anus clean, for the anus is easily soiled in voiding flatus. The anus should be washed with soap and water and dried with wool after each action. Irritation at night may be relieved by the application of carbolic lotion (1 in 20) on lint.

(*b*) Of the second stage. When the skin has become chronically inflamed it requires more active treatment than just described. It is well worth while, especially if any operation has first to be performed in the anal canal, to keep the patient lying up and to take infinite pains to cure the dermatitis.

A good plan is to begin with hot fomentations until the skin appears clean and supple, and to continue by painting with 2 per cent. solution of iodine in spirit every third day. In the intervals the part must be kept clean and dry, either with a powder or astringent lotion, *e.g.*, zinc oxide and borochloretone (equal parts) or lotio calaminæ co. (St. Bart.'s Hosp. Pharmacopœia). The drugs that may be used in ointments to relieve irritation are legion. Among the most useful are resinol, ichthyol, chloretone, and carbolic acid.

Perhaps the most efficient method of curing the skin infection and relieving irritation is by ionisation with zinc or iodine. Unfortunately improvement and cure are seldom permanent. In order to get the zinc to penetrate between the folds of skin it is best to apply it in the form of a paste by mixing the zinc sulphate solution with powdered china clay.

(*c*) Of the third stage. Long-standing cases require radical treatment, and when the anal canal is the source of the trouble Whitehead's operation will often result in a cure.

Ball's operation may also be recommended for intractable cases. The skin around the anus is dissected up by elliptical incisions on either side from the underlying tissue so that all the cutaneous nerves are cut. This dis-

section is continued well up into the anal canal, and then the incisions are sutured and firm pressure applied. Both these operations are uncertain in their results, and a percentage of failures must be expected.

In troublesome cases relief and even cure sometimes follows the use of X-rays or radium. Autogenous vaccines may be tried.

## Proctitis.

The rectum, like the pharynx, is subject to an *acute catarrhal inflammation*, characterised by redness, œdema of the mucosa, and excessive secretion. If the condition becomes chronic, the mucosa becomes granular and bears a close resemblance to the mucosa in chronic pharyngitis. This infective condition follows local irritation, *e.g.*, traumatism from a foreign body, or impacted fæces, threadworms in children, irritating rectal injections, drugs producing violent purgation, etc. Not infrequently the pelvic colon is also involved.

An acute suppurative proctitis may result from a gonococcal infection.

Chronic proctitis may follow an acute attack or be associated with a chronic ulcerative colitis. A hæmorrhagic form is occasionally met with, usually in young women.

*Symptoms.*—Pain, tenesmus, the frequent passage of mucus, and occasionally blood, are the main symptoms, with diarrhœa if the colon is also involved. In acute cases there is constitutional disturbance and malaise resembling an "acute cold."

*Treatment.*—The cause of the inflammation must be ascertained and dealt with. In acute cases the patient should be confined to bed on a fluid diet and the rectum irrigated daily with cold saline or, if congestion is severe, with hazeline solution. Tenesmus is relieved with morphia and belladonna suppositories.

The most effective treatment for a chronic infective condition of the rectum is ionisation, and the best metal for the purpose is zinc. Herschell's electrode, covered by a membranous bag which is filled with a 2 per cent. solution of zinc sulphate, is used. No anæsthetic is required in the majority of cases. The current employed depends on the extent of the inflammation and how much the patient can stand. After two or three applications at intervals of a week patients usually become more tolerant. About 10—15 milliamps. for 10—15 minutes is sufficient for the initial treatment, and this may be gradually increased up to 30 milliamps. for as long as 30 minutes.

**Ulcerative proctitis.**—1. *Post-operative or traumatic.*—Before the days of antiseptic surgery ulceration of the lower end of the rectum and anal canal not infrequently followed an operation for piles, etc. The infection, once introduced, would rapidly spread through a ward of rectal cases, by the use of dirty enema nozzles, etc.

Even at the present day some flaw in technique during an operation may be followed by septic ulceration of the rectum. Apart from surgical trauma, septic ulceration occurs after injury from foreign bodies.

*Treatment* consists in securing rest for the part and providing free drainage by dilating the sphincter and employing rectal irrigation during the acute stage, and by ionisation after acute symptoms have subsided. Fibrous stricture (p. 1008) is very liable to follow, unless treatment with bougies is carried out after the ulcers have healed.

2. *Follicular ulceration.*—Acute or chronic proctitis may be followed by the breaking down of the solitary lymphoid follicles. When this occurs the

sigmoidoscope may reveal shallow, minute discrete ulcers scattered over the rectal mucosa. The condition is not often painful and usually responds to treatment by ionisation, though in obstinate cases appendicostomy may be necessary to secure more efficient cleansing and relief from irritation.

3. *Syphilitic ulceration.—Tertiary gummatous ulceration* of the rectum is very rare, and the statement that syphilis is one of the causes of stricture must be accepted with considerable reserve. Primary soft sores are occasionally met with in women. The moist mucous patches or condylomata so common round the anus in secondary syphilis deserve to be mentioned under this heading because of the risk involved in digital examination when these are present.

4. *Tuberculous ulceration of the rectum and anal canal.*—When tuberculous ulceration occurs in the colon it usually extends to the rectum, and will readily be recognised with the sigmoidoscope. In an early stage the ulcers are small and shallow, and small grey nodules may be seen. A common situation for an ulcer is on the upper surface of one of Houston's valves, where it may easily be missed with the sigmoidoscope unless carefully looked for. Tuberculous ulceration of the rectum progresses very rapidly, especially when associated with advanced phthisis. The ulcers enlarge and fuse together, the edges become undermined, and in a few weeks little of the normal mucosa may remain.

High up, perforation may occur into the peritoneal cavity; low down, the ulceration may extend into the bladder or vagina, resulting in recto-vesical or recto-vaginal fistula. More often ulceration invades the ischio-rectal fossa, and a tuberculous fistula-in-ano results (*vide infra*). Occasionally the stress of the ulceration falls on the anal canal, followed by fistulous tracks in all directions. Fibrosis with resulting stricture is rare in tuberculous ulceration of the rectum, but it is occasionally met with.

*Treatment*, as in other forms of infective proctitis, is most disappointing. When associated with ulceration of the colon, appendicostomy, combined with irrigation both from above and below, should be employed if the condition of the patient permits. Some temporary improvement in the rectal condition, and often considerable relief of pain, may be obtained by ionisation with a solution of zinc sulphate.

*Tuberculosis of the anal skin.*—This is a rare condition. Small greyish nodules may be observed close to the anal margin, quite unlike the flattened moist condyloma, and not to be confused with the tuft-like anal papilloma. If these are not promptly excised, a tuberculous ulcer results and quickly extends. The condition occurs independently of recto-anal tuberculosis, and the term " verrucous tubercle " has been given to it.

## Stricture of the Rectum (non-malignant).

Inflammation followed by ulceration, if untreated, will result in fibrosis and stricture. When malignant disease and the few rare cases of stenosis resulting from congenital malformation are excluded, practically all cases of rectal stricture result from septic ulceration, a subject which has already been discussed.

Strictures due to gonorrhœa are not common, and to tubercle or syphilis very rare. A few cases occur after rectal sloughing following parturition. Prio to the formation of a stricture the mucous membrane is destroyed and replaced by fibrous tissue. When this occurs over an extensive area a tubular st icture results. More commonly the stricture is annular and frequently

situated either at the junction of the pelvic and perineal portions of rectum or at the junction of rectum and anal canal.

*Anal stenosis* occasionally follows Whitehead's operation for piles, and sometimes also occurs after the ligature operation when an excessive amount of mucous membrane has been removed, or it may follow the operative treatment of extensive fistulæ, and is due to the excessive formation of fibrous tissue within the sphincter. This condition should never occur after a properly conducted operation for hæmorrhoids, and is due either to operative sepsis or to healing by granulation without careful after-treatment.

When a stricture has formed in the rectum, secondary ulceration above the stricture from fæcal stagnation often occurs (stercoral ulcers), and in rare instances one of these may perforate into the peritoneal cavity. Occasionally polypi form above, and may be so elongated as to protrude through the stricture.

Inflammatory stricture never occurs without considerable fibrous thickening of the rectal wall and destruction of the mucous membrane. In long-standing cases the fibrous canal may be lined by pavement epithelium.

*Symptoms.*—An anal stricture is often associated with impaired sensation and some incontinence, especially of flatus. In severe cases defæcation is difficult and painful.

Stricture of the rectum may be well advanced before causing noticeable symptoms. Usually there is a muco-purulent discharge, which may be copious and offensive, but pain is seldom a prominent feature. When the lumen is considerably obstructed there is constipation alternating with spurious diarrhœa, which is produced by irritation of the mucosa from fæces retained above the stricture.

*Treatment.—Dilatation* with soft rubber graduated bougies (Wales's pattern) or Hegar's uterine dilators must be employed in the first instance. This must be carried out slowly and gradually with great care, especially in high strictures, to avoid accidental perforation of the bowel above the stricture. The soft flexible bougies are the safest for high stricture.

Dilatation should be followed by antiseptic irrigation and ionisation to secure healing of the ulceration. Low-lying strictures, if very dense, may be treated by *linear proctotomy, i.e.*, by division of the stricture posteriorly by an incision which divides the sphincters and all tissues right back to the coccyx.

An annular stricture at the anus can be treated by a modified Whitehead's operation.

An annular stricture involving the perineal portion and clear of the anal canal may be excised (and the bowel united) by a sacro-anal excision after removal of the coccyx. In the presence of much inflammatory tissue the operation is a difficult one and the chances of securing a sound union after excision very uncertain.

In severe cases, where there is considerable ulceration and septic absorption it is advisable to perform a *temporary colostomy* before taking steps to cure the condition.

## Ano-rectal Abscess.

Abscesses in this region in most cases result from abrasions in the anal canal, followed by infection.

They may be classified according to their position as :—

1. *Subcuticular, or peri-anal.* 2. *Submucous.* 3. *Ischio-rectal.* 4. *Pelvi-rectal and retro-rectal.*

1. **The subcuticular** is a superficial abscess at the anal margin between the skin and the sphincter (Fig. 406, C), and is usually secondary to a fissure or a thrombotic external pile. It should be opened by a free incision extending outwards beyond the abscess margin, and the overhanging margins must be excised. Unless this is done a marginal fistula is liable to occur.

2. **The submucous abscess** (Fig. 406, B) is met with between the mucous membrane and the muscular coat of the rectum. Usually it empties itself into the bowel before attaining any size and soon develops into a submucous fistula. Careful examination under an anæsthetic will reveal the opening at the ano-rectal junction in the position of one of the valves. Owing to the external sphincter being normally in a state of tonic contraction, foreign bodies and hard scybala, etc., are liable, when arrested at this level, to cause an abrasion.

The abrasion is followed by an ulcer, and then by an abscess, which will tend to track in the direction of least resistance, either beneath the loose mucous membrane of the rectum, where it joins the anal canal (submucous abscess), or between the two sphincters (following branches of the inferior hæmorrhoidal vessels), towards the ischio-rectal fossa (ischio-rectal abscess).

When the abscess is pent up and confined to the submucous region within the bowel, pain is usually severe. Relief comes with discharge of pus from the bowel. If untreated a submucous fistula results, a condition which may easily escape detection and one which is often responsible for severe spasmodic attacks of rectal pain, due to the ulceration at this extremely sensitive area.

*Treatment* consists in dilating the sphincter and laying open the upward track, with due regard for the hæmorrhoidal vessels.

If the abscess is extensive or has begun to burrow towards the ischio-rectal fossa, the external sphincter should be divided.

3. **Ischio-rectal abscess.**—As already stated, suppuration commencing at the ano-rectal junction may track between the sphincters into the loose areolar tissue of the ischio-rectal fossa. In the great majority of ischio-rectal abscesses (which are more common than the submucous variety) a communication with the bowel can be traced if carefully searched for in the *right situation*. The starting-point of infection, *i.e.*, the site of the original abrasion, is nearly always posterior in the immediate neighbourhood of one of the valves of Morgagni and at the interval between the sphincters.

It is customary to blame fish-bones, bone fragments, and other foreign bodies which have been swallowed for ischio-rectal abscess and fistula. No doubt, foreign bodies are often responsible for the original injury, but it is quite the exception to find a foreign body in the abscess cavity or in the track of a fistula. It is probable that constipation with hard motions is as much, or more, to blame than any foreign body. Although an ischio-rectal abscess usually commences as described above, it occasionally results from blows or injury to the ischio-rectal fossa itself. The loose tissue in this area, so close to the bowel, provides a favourable site for infection when a hæmatoma forms.

Tuberculous patients seem to be especially liable to ischio-rectal abscess, and some chronic fistulæ are definitely tuberculous (*vide infra*).

In other instances a peri-anal abscess may track into the ischio-rectal fossa (Fig. 406, D). In these cases there will be no opening between the sphincters.

*Symptoms.*—When acute, the pain, swelling, redness, and fluctuation make diagnosis easy. Not infrequently the abscess starts insidiously, then reaches an acute stage, and only attracts attention by discharge of pus *per rectum* or by a sense of rectal discomfort associated with general malaise.

In rare instances the condition is bilateral, spreading to the opposite side behind the rectum.

*Treatment.*—A chronic ischio-rectal abscess is the forerunner of most fistulæ. It must be opened by a T-shaped incision so as to secure free drainage. A free incision is made at right angles to a radius from the centre of the anus, and from the middle of this incision a radial incision is made outwards. The angles of skin are then removed, leaving a triangular opening. If an opening exists, as it usually does, into the bowel between the sphincters, it is advisable to lay this open by division of the external sphincter some ten days later, when active suppuration has subsided. The abscess cavity should be lightly packed, and not stuffed, with wool, and fomentations applied for two or three days. When acute symptoms have subsided, the patient should take a bath daily. The bath allows the dressing to soak off without injury to the granulations. The cavity should be sponged twice daily with peroxide so long as discharge is present.

4. **A pelvi-rectal abscess** extends up between the bowel and the levator ani (Fig. 406, A.). In some instances a pelvic abscess, in connexion with the appendix, uterus, etc., may make its way downwards to the rectum and simulate the pelvi-rectal abscess, which originates from the bowel and has the same starting point as other abscesses in this region, from the ano-rectal junction.

FIG. 406.—Diagrammatic representation of the common types of fistula-in-ano. A, Pelvi-rectal. B, Sub-mucous. C, Sub-cuticular (peri-anal). D, Ischio-rectal.

The condition is a serious one, gives rise to severe constitutional symptoms, and requires prompt treatment.

*Treatment.*—It is necessary to make an incision through the ischio-rectal fossa, or behind the anus to one side of the middle line when the abscess is retro-rectal, and to reach the abscess by passing a director upwards through the levator ani, guiding the director with a finger of the left hand in the rectum. The opening must then be freely dilated, so that a tube can be passed into the cavity. Frequent irrigation is necessary during the acute stage, and great care and much patience is required to secure sound healing.

Fortunately suppuration in this region is of rare occurrence.

## Fistula-in-ano.

The abscesses which have just been described, if neglected, give rise to fistulæ in corresponding situations (Fig. 406) :—

The main cause for the formation of a fistula is *inefficient drainage*, due either to the fact that when an abscess forms and bursts it does not receive efficient treatment or, as is frequently the case, receives no treatment at all.

The position of the internal opening between the active sphincters prevents both adequate rest and drainage, and allows of frequent contamination from the bowel and escape of fæcal matter into the track. With the exception of those cases of suppuration which arise from a primary abscess in the ischio-rectal fossa, all fistulæ communicate with, or have at some time had connexion with, the bowel in the region between the sphincters.

In the majority an external opening also exists, and there may be more than one. In complicated cases with considerable burrowing secondary openings may occur at some distance from the anus. The external opening is usually quite small and appears as a minute dimple with a button-like projecting granulation. Fistulæ are therefore described as :—

1. Complete.
2. Incomplete.
   (*a*) Blind internal.
   (*b*) Blind external.

As stated above, the complete are most common.

1. **The complete fistula.**—When the external opening is situated in front of a line drawn transversely across the anus the fistulous track usually takes a direct course to open into the bowel at the ano-rectal junction, so that a director passed along the track will travel in a straight line to the internal opening. Behind this line, whatever the situation of the external opening, the internal will nearly always be found to be posterior.

The majority of fistulæ are of the posterior variety. Very often from the posterior opening the track bifurcates to either side and a *horse-shoe fistula* results (Fig. 407). Usually, but not always, both branches of the horse-shoe have an external opening. Wherever a track exists it can be felt with the finger as an indurated cord beneath the skin.

*Anterior horse-shoe* fistulæ are not nearly so common.

*Submucous tracks* may occur, either as independent fistulæ or as side-tracks to the complete variety. There may be several external openings to a fistula, but the internal opening remains constant and single at the inter-sphincteric line, though in exceptional cases a submucous track may break into the bowel higher up, forming a secondary opening. The tracks are lined with granulations and the walls consist of fibrous tissue, which increases with the age of the fistula.

Although in the majority of cases the track of the fistula runs out between the sphincters to the ischio-rectal fossa, yet in many the track passes outwards superficial to the external sphincter. Owing to the large amount of fibrous tissue formed, incision of the track in these cases gives rise to the belief that the external sphincter has been divided, when in reality only new fibrous tissue has been cut by the bistoury.

2. **The incomplete fistula.**—The blind internal are usually submucous, peri-anal, or pelvi-rectal (very rare), or an early stage of the ischio-rectal.

The blind external result from the primary ischio-rectal abscess.

In many cases, when a diagnosis of blind external fistula is made, it is probable that an internal opening has either closed or really exists, though undiscovered.

In the peri-anal variety there may be only one opening, which may be either just within or without the true anal margin, and whether it is called a blind internal or external matters little.

*Symptoms.*—The fact that fistulæ are allowed to form at all and that advice is often not sought until the condition has existed for months, or even years, shows that the symptoms are often of little import to the patient. A slight,

and it may be daily, constant discharge from an external opening will distress the well-to-do and the cleanly, but may hardly attract the attention of the hospital class.

Pain only occurs when the discharge, from some cause, is obstructed and, accumulating, gives rise to tension. It will bring the patient to the out-patient room far more often than a chronic discharge.

As might be expected, fistulæ are far less common in the well-to-do than in hospital patients.

*Diagnosis.*—A fistula can be diagnosed by feeling the indurated track between a finger in the rectum and one outside. The internal opening can sometimes be felt, but is identified with a speculum. Blind internal fistulæ may require an examination under an anæsthetic. The passage of a probe-pointed director for diagnosis causes pain and is usually unnecessary.

Urinary fistulæ must be excluded and one in connexion with malignant disease or disease of the bone kept in mind. Tuberculous fistulæ are considered separately below.

It should not be forgotten that in rare instances malignant disease has originated in the track of a fistula.

*Treatment.*—Although in exceptional cases fistulæ close spontaneously, an operation as a rule is required. The chest should always be examined and the urine tested for albumen. The essential point in operating on a fistula is to secure *thorough drainage* by completely laying open all tracks and by excising all overhanging skin. There is no danger of removing too much skin; there is always plenty to spare in the perineum.

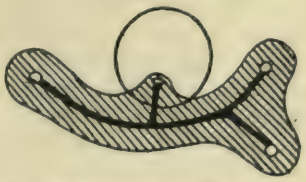


FIG. 407.—Diagram to illustrate a horse-shoe fistula. The black line shows the fistulous track, the small white circles the openings of the fistula within and without the bowel, and the shaded area indicates the tissue exposed after operation.

*Excision and suture* of a fistulous track is seldom successful, and a second operation is usually required. The skin may heal up at once, but the bowel area lags behind and drainage becomes inefficient. The method is obviously unsuitable for a complex fistula, though it may be tried for a simple direct fistula in one of the anterior quadrants.

*Simple incision of fistula, leaving the wound open.*—This is usually the operation of choice. In a simple case a probe-pointed director is inserted through the external opening and manipulated till it engages the internal opening. All tissues superficial to the director are then incised together with the external sphincter when it is included. The overhanging margins of skin are freely removed and the granulation tissue scraped away. If there is much fibrosis, the fibrous tissue may either be incised to establish a better blood supply for healing (Salmon's method of "back cut") or freely excised.

If the opening into the bowel is lateral, great care is necessary to avoid cutting the sphincter obliquely. The wound should be lightly filled with wool.

*Complicated fistula.*—When the track to the bowel is not direct the superficial portions must be first laid open and the communication with the bowel established by an incision at right angles to the fibres of the sphincter (Fig. 407). If after opening the fistula into the bowel a submucous track is found, it should be stretched and packed (or a small tube inserted), but the bowel should not be further incised.

*Horse-shoe fistula.*—The lateral tracks are first freely opened up to their

full extent. The opening into the bowel must then be incised in the posterior or anterior line as the case may be (Fig. 407).

Very large fistulæ of this nature are best treated in two stages to avoid undue retraction of the bowel. The opening into the latter is made at a later stage, when cicatrisation has commenced.

*After-treatment.*—Strict cleanliness is essential and the wound should be washed with peroxide at least twice a day, preferably after action of the bowels, and subsequently lightly packed with wool. After the bowels have been opened for the first time on the morning of the fourth day the patient should take a bath daily, when the dressing will soak out. For the first three or four days hot fomentations are advisable.

Most fistulæ, if carefully treated, heal in from four to seven weeks, according to the size of the wound.

Fistulæ which are slow to heal may be stimulated by scarlet-red ointment or by the use of blue stone (copper sulphate). Deep pockets, especially in the retro-rectal space, are often very chronic. Zinc ionisation is useful in those cases.

**Tuberculous fistula-in-ano.**—Whereas in the great majority of cases the non-tuberculous fistula is the sequel to an abscess, ischio-rectal or anal, and is acute in origin, the tuberculous fistula is from the first usually a chronic condition and commences insidiously. It is characterised by extensive undermining of the skin, which is blue and boggy, with little or no induration of the surrounding parts. The internal opening between the sphincters is usually large, ragged and ulcerated, and the external, instead of presenting a button-like granulation, is patent and irregular. Owing to the absence of acute inflammation and induration, and consequently of pain, the condition may not attract attention in the early stages. In the majority pulmonary tuberculosis is present and is usually advanced.

Although in cases of tuberculous fistula phthisis is more often present than not, fistula is a comparatively rare complication of pulmonary tuberculosis. Dr. Hugh Walsham found that, at the City of London Chest Hospital, in 891 cases of tubercle of the lung, fistula was present five times and ischio-rectal abscess twice, and that in 133 post-mortems after death from phthisis there was only one *fistula-in-ano*. A fistula occurring in a tuberculous patient is not necessarily tuberculous in origin, though it is liable to become so if neglected. A simple fistula in a tuberculous subject, if treated early, will readily heal, whereas a fistula, the result of active tuberculosis, is much more intractable if the disease of the lung is also active.

If the fistula is tuberculous in origin, the tubercle bacillus may be found either in the discharge or in the walls of the sinuses. It is generally believed, and some text-books support this view, that about 10 per cent. of all cases are tuberculous. This figure is far too high ; at St. Mark's Hospital the percentage of tuberculous fistulæ is not greater than 3 per cent.

*Treatment.*—It was a tradition in the past that tuberculous fistulæ should not be operated on. It was contended that the fistula acted as a safety-valve to the lungs, and relief or cure of the fistula accelerated the pulmonary mischief. At the present time no such belief as this holds ground. There can be no doubt that progressive ulceration, subcutaneous fæcal extravasation, and painful defæcation can have no beneficial effect on the local condition in the lungs or on the general condition of the patient. On the other hand, considerable relief, both bodily and mental, can be obtained by operation if the cases are judiciously selected, and in a certain percentage a complete cure of the fistula will result.

If a patient is the victim of acute phthisis and cannot live long, no operation is advisable. The most that can be done is to relieve pain by simple incision under local anæsthesia. If a radical operation is attempted no benefit will accrue; it will be followed, not by healing, but by progressive ulceration, and the last state will be worse than the first. If a patient has been the subject of active phthisis, but is at the time of consultation on the road to, or far advanced towards, recovery, more active treatment may be employed and with more prospect of success. In these cases the external sphincter should be dealt with sparingly and the internal religiously avoided. It is a noticeable feature of tuberculous fistula that the sphincters are weak and flaccid, and do not readily recover their tone when once divided.

In cases of tuberculous fistula, with no evidence of tubercle elsewhere, early radical operation is most important to remove a possible source of general infection. A general anæsthetic, and especially ether, should be avoided in all cases in which pulmonary disease co-exists. Either local or spinal anæsthesia should be used. The patients should not be confined to bed after the first day, nor should they be kept in the recumbent position. Fresh air and sunshine, with cheerful surroundings and good food, are important details in accelerating recovery. The consumptive who develops a fistula takes a gloomy view of life, and the success or failure of the surgeon depends not a little on apparent trifles.

## Tumours of the Rectum.

**Innocent tumours.—Adenoma, or mucous polypus.**—An adenoma is a tumour with a connective-tissue stalk covered by the ordinary rectal mucous membrane. It is usually sessile at first, but later becomes pedunculated owing to traction exercised by the bowel in attempting to expel it. As a rule only one polyp is present, but multiple adenomata may occur scattered all over the rectum as over the rest of the large intestine. Occasionally simple adenomata are met with below a carcinoma which may have originated from one of these innocent growths.

*Clinical signs.*—A single polypus is generally met with in children. The main symptoms are irritability of the rectum and a frequent desire for stool caused by the presence of a foreign body in the rectum, associated with a discharge of mucus and sometimes blood from the bowel. During defæcation the tumour may be extruded from the anus and, if caught by the sphincter and not replaced, may be torn off. The strong efforts of defæcation may produce considerable prolapse of the mucosa.

On digital examination the tumour may be detected by sweeping the finger round the bowel so as to catch the pedicle.

*Treatment.*—This consists in dilating the sphincter, applying a ligature by transfixion round the pedicle as high as possible and snipping off the polypus. In the case of sessile tumours the wall of the rectum may need to be sutured with catgut.

**Villous tumour** is a somewhat rare adenomatous tumour which has a shaggy appearance something like a villous growth in the bladder. It is liable to be mistaken for carcinoma and, indeed, is very liable to become malignant. Absence of induration or fixation to the muscular wall and the villous nature of the surface should serve to establish its innocency, but it is advisable to obtain a portion for microscopic section, if possible, before operation.

A villous tumour is seldom pedunculated and often grows to a considerable size (Fig. 408).

*The treatment* consists in removal of the tumour (which is generally sessile) together with a portion of the rectal mucous membrane. If the tumour involves more than half the circumference it will be necessary to resect a portion of the rectum by the sacro-anal method.

**Malignant tumours.—Carcinoma** may originate in the rectum or anal canal; in the former case it is columnar-celled, and in the latter it may be either columnar-celled or squamous-celled.

Fig. 408.—Villous tumour of the rectum. (St. Bartholomew's Hospital Museum.)

The common situations for growths are :—

1. At the recto-sigmoidal junction.
2. In the ampulla (extra-peritoneal portion of the rectum).
3. In the anal canal.

Carcinoma of the rectum occurs most frequently after forty, but may attack even the young adult (Fig. 409). The earlier the onset the more rapid the growth. When carcinoma of the rectum occurs in patients under thirty the condition may be regarded as hopeless and beyond the reach of surgery from the point of view of a radical cure.

*Morbid anatomy.*—Carcinoma starts as a small hard growth, though sometimes it has its origin from a simple adenoma.

It tends to enlarge circumferentially. At first it moves with the mucosa on the muscle, but soon becomes fixed to it, and later infiltrates it. As

the infiltration extends to the peri-rectal tissues the growth may become fixed to the prostate, bladder or vagina, and by invading these organs give rise to recto-vesical or recto-vaginal fistula; or by invading the ischio-rectal fossa produce a "fistula-in-ano." As the tumour increases in size its edges become heaped up and the centre ulcerates. Usually it is not till the stage of ulceration is reached that pain and bleeding attract attention to the disease.

While the growth is spreading locally and infiltrating the surrounding tissues the lymphatics are invaded.

The lymphatic spread follows the superior hæmorrhoidal veins, meeting glands beside and behind the rectum, and, extending upwards, involves the

FIG. 409.—Section through the rectum and upper portion of the vagina of a young woman, showing a colloid carcinoma of the bowel. A, Lumen of the rectum. B, Semi-translucent growth. C, Cervix. D, Vaginal fornices. (St. Bartholomew's Hospital Museum.)

lymphatics and glands in the pelvic meso-colon, and thence advances to the lumbar glands.

Simultaneously the blood-stream may be involved and secondary deposits appear in the liver and occasionally in other organs. Secondary growths are sometimes met with in the skin over the abdomen and chest. When the tumour involves the anal canal the lymphatics which follow the inferior hæmorrhoidal vessels are involved, and so the inguinal and thence the iliac glands are invaded.

In the upper end, or peritoneal portion of the rectum, the type of growth most often met with is the "ring" type. The growth is then small and fibrous, and rapidly surrounds the bowel and constricts it.

In the ampulla, or extra-peritoneal portion, the growth has usually reached a considerable size before it surrounds the bowel. Frequently in this situation it extends rather by deep infiltration than by centrifugal spread, and this is

especially the case with growths that commence on the anterior wall and become fixed to the prostate and base of the bladder in the male, or vagina in the female.

*Clinical symptoms.*—(*a*) *Early stage.*—It is of paramount importance that the disease should be recognised at an early stage, when it is still amenable to surgical treatment. Unfortunately it is very insidious in its onset, and may exist for six months or more before symptoms occur which compel a patient to seek a rectal examination, or which awaken the suspicion of the medical attendant that there is some serious disease.

Often the first sign noticed by the patient is a discharge of blood; this means that the growth has disintegrated and ulcerated, and is probably already of large size. The endeavour of the clinician is to make a diagnosis at a much earlier stage. One symptom is commonly present, namely, a prolonged and well-marked attack of constipation appearing in one whose bowels have previously acted regularly without the aid of aperients. After this, diarrhœa, slight at first, becoming more marked as time goes on, supervenes. During this time the patient's health may remain good; he may not lose weight appreciably, and consequently attaches no particular importance to his condition, and seeks relief only for the regulation of the bowels.

Too often such a patient is given medicine without an efficient examination. It cannot be insisted on too strongly that a digital examination of the rectum and, if necessary, examination with a sigmoidoscope should be made in every case in which diarrhœa supervenes upon an attack of constipation and persists in an otherwise healthy individual, more especially if he has reached the age of fifty and is losing weight.

(*b*) *The later stage.*—When the growth is well established and disintegration of the centre of the tumour has occurred with the formation of an ulcer, the clinical signs are as a rule well marked and obvious. They are:—

1. Increased frequency in the action of the bowels.
2. The appearance of blood in the stools; it must be remembered that piles may co-exist and account for this.
3. The appearance of offensive mucus, often discharged apart from the stool.
4. Pain in the rectum and in the region of the sacrum.
5. The presence of tenesmus. The existence of a growth in the rectum gives rise to the sensation that the rectum is not completely emptied, and consequently the patient continues to strain after the rectal contents have been voided.
6. Progressive loss of weight.

(*c*) *When almost complete occlusion of the lumen of the bowel has occurred.*

This does not occur in all cases, and is becoming much more rare now that patients are examined and treated earlier. The symptoms of this stage are very obvious:—

1. Obstinate constipation, alternating with diarrhœa.
2. Increasing abdominal distension, with visible intestinal peristalsis.
3. Rapid emaciation.
4. Vomiting.
5. Attacks of absolute constipation.

*Physical examination.*—In a suspected case the rectum should be examined to the full extent of the finger, and if a tumour is found, its position, extent, and characters should be noted. Special care should be taken to observe whether the growth is movable on the muscular layer of the bowel, or on

the surrounding structures, in order that the possibility of removal may be ascertained.

Next the abdomen must be examined for enlargement of the iliac and lumbar glands and for enlargement of the liver as denoting metastatic deposits.

Should no growth be felt with the finger, the sigmoidoscope should be used.

*Differential diagnosis.*—The following conditions may be mistaken for carcinoma :—

1. Innocent growths– adenoma and villous tumour.
2. Non-malignant strictures.
3. Hyperplastic tuberculosis and diverticulitis of the pelvic colon.
4. Rare cases of sarcoma and gumma.

*Treatment.*—In the case of carcinoma of the rectum, as in carcinoma of other regions, the only possible chance of a radical cure lies in an early and complete eradication of the disease by operation. Radium, while useful in checking the growth of an inoperable carcinoma, cannot be advocated as a curative measure. When the rectum is attacked by a carcinoma it should be regarded as functionally lost, as in the case of the breast, and measures should be taken, when possible, for its complete removal together with the associated lymphatic glands.

For purposes of treatment cases of carcinoma of the rectum may be divided into two classes, namely, (*a*) those in which complete removal is practicable, and (*b*) those in which it is not.

FIG. 410.—Columnar-celled carcinoma of rectum with a papilloma hanging down on the right of the specimen. Secondary glands in meso-rectum. Specimen removed by abdomino-perineal excision. (St. Bartholomew's Hospital Museum.)

(*a*) **Cases in which complete removal is practicable.**—The important points for consideration are :—

1. *The depth of infiltration of the rectal wall and neighbouring viscera.*—If the growth affects only the rectal mucous membrane, it is removable. If it has passed through the mucous membrane and has reached the muscular wall it is still removable, provided the peri-rectal tissue is unaffected. If the growth has passed beyond the rectum and infiltrated neighbouring viscera, such as the bladder, vagina, uterus or prostate, or is fixed to the sacrum, it is not removable.

2. *The existence of metastatic deposits in the lymphatic glands, peritoneum, and abdominal viscera.*—The enlargement of pelvic lymphatic glands does not preclude the possibility of removal; the enlargement of the lumbar glands,

peritoneal deposits, and metastases in the abdominal viscera render complete removal impossible.

When the growth is situated so high up in the rectum that the upper limit cannot be felt, or when the growth is entirely beyond reach of the finger, it may be necessary to open the abdomen so that, with the hand in the pelvis, the above-mentioned points may be ascertained with accuracy.

In the event of the growth proving to be removable, several operations are

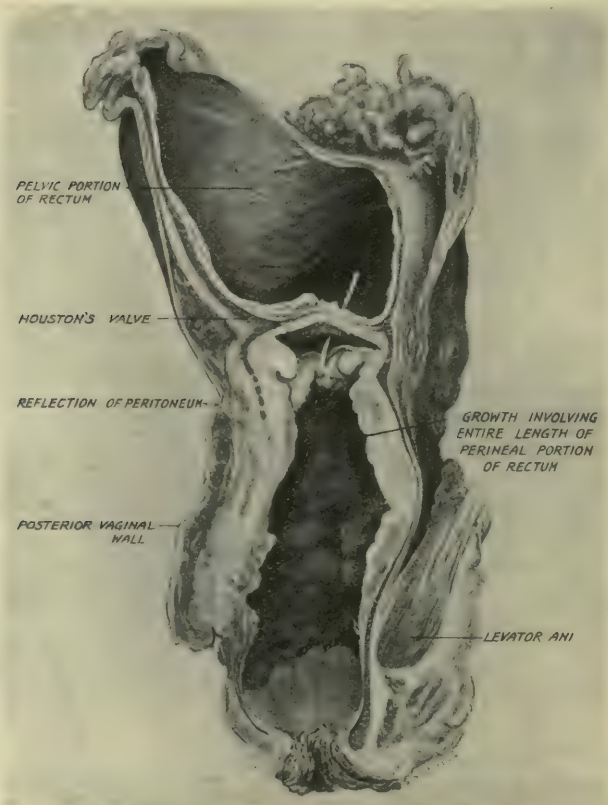



FIG. 411.—Specimen removed by perineal excision of the rectum for carcinoma of the perineal portion. Part of the vaginal wall and the entire rectum have been excised. Houston's valve between the two portions of the rectum is well shown, the lumen of the bowel being indicated by a glass rod.

possible, for details of which the student is referred to a text-book of operative surgery.

The ideal operation is one that comprises complete removal of the rectum together with the lymphatic vessels, lymphatic glands, and cellular tissue in the hollow of the sacrum, combined with the formation of a left inguinal colostomy. Anything short of this is not a radical operation, and though life may be prolonged by a local excision of the growth, recurrence must be expected when the glands are not removed.

*The abdomino-perineal operation.*—The ideal is best attained by this operation, which consists, firstly, in dividing the pelvic colon transversely

and performing an inguinal or hypogastric colostomy. Then the lower part of the pelvic colon, together with the upper part of the rectum, is freed from its attachments to the peritoneum and the bladder or vagina, and is pushed down into the pelvis. The peritoneum of the pelvic floor is sewn up over the detached bowel and the abdomen closed. The next stage of the operation is done through the perineum. An incision is made round the anus and, after excising the coccyx, the entire bowel is removed together with the fat and lymphatic vessels in the hollow of the sacrum and in the ischio-rectal fossa, with which is included as much of the levatores ani as possible

The danger of this operation is considerable, on account of the severe shock produced, and the great risk of peritonitis and pelvic sepsis.

The death-rate is exceptionally high, and though with improved technique the mortality has diminished, it is probably not lower than 25 per cent. even in experienced hands. Patients over sixty, unless young for their age, are more likely to succumb than recover. Stout patients, especially if subject to bronchitis, are unsuitable subjects. Women stand the operation much better than men. The female pelvis gives more room to the operator, and is more tolerant of interference; the pelvic floor is more easily closed owing to the presence of the uterus.

*Perineal excision with preliminary and permanent colostomy.*—This operation, though not so radical as the abdomino-perineal, can be performed with comparative safety, and the mortality is not more than about 5 per cent. It is most suitable for growths in which the upper limit is within reach of the finger with a bimanual examination, *i.e.*, growths mainly, if not entirely, below the peritoneal reflection (Fig. 411). Small movable growths in the peritoneal portion of the rectum can also be removed by this method. An anæsthetic is often necessary to ascertain if the case is suitable.

The essential points of the operation are :—

1. Wide excision of skin round the anus (which is sutured up), with the removal of the coccyx and contents of the ischio-rectal fossæ.
2. Division of levatores ani high up.
3. Opening the peritoneal cavity and drawing the rectum down so that it can be divided well above the growth.
4. Division of the bowel with the cautery and closure of the upper end under aseptic precautions.
5. Suture of stump to peritoneum.
6. Complete closure of perineum with drainage for twenty-four hours only.

*To summarise the operative treatment.*—When operation is considered advisable the abdomino-perineal alone is suitable for high growths.

In low growths, perineal excision with colostomy has a much lower mortality, but probably does not offer quite so good a prospect of freedom from recurrence. In view, however, of the high mortality of the abdomino-perineal operation, in most cases perineal excision is preferable.

Trans-sacral operations are not recommended.

(*b*) **Cases in which complete removal is not practicable.**—Unfortunately this class is all too common because the disease is too far advanced when it first comes under the notice of the surgeon. As soon as it is decided that the case is unsuitable for removal the question arises as to the best course to pursue. It allowed to proceed unchecked, obstruction of the lumen of the bowel is almost certain to occur, requiring sooner or later the formation of an artificial anus by left inguinal or hypogastric colostomy. Colostomy should be performed at an early stage, before the onset of obstruction, for by this means the patient is relieved of the discomfort of constant diarrhœa

and the pain caused by fæces passing over the ulcerated surface of the growth ; moreover, there is evidence that a growth in the rectum will not develop so rapidly if it is not continually irritated and if the blood supply of the part is diminished by disuse. The growth is more easily treated by radium after colostomy has been performed. After colostomy the patient should be fitted with a belt.

Hypogastric colostomy, in which the artificial anus is made through the rectus muscle instead of through the obliques as in inguinal colostomy, gives rather better results as regards control, and is certainly better for the colostomy belt and cup. The cup keeps in position better and does not tend to ride upwards, as it often does in the inguinal region owing to the movement of the iliac crest. The patient should be taught to control and regulate the action of the artificial anus by washing out the colon once a day regularly with plain water, using $1\frac{1}{2}$ to 2 pints.

The growth should be kept clean by a daily wash from above.

*Treatment by radium.*—Carcinoma of the rectum is suitable for treatment by radium, because the tube can be embedded in the growth. It must be remembered that a cure by this means cannot be expected, although the progress of the disease may be materially checked.

*Treatment by diathermy.*—This method is useful in those inoperable cases in which the growth is exuberant and in which a colostomy has been performed. By its action the rapidity of growth of a carcinoma may be hindered, but it will not be cured.

Both radium and diathermy are of considerable value in the treatment of recurrent growths following removal.

**Sarcoma.**—Sarcoma of the rectum is rare. Clinically it is seldom recognised without microscopic examination.

The clinical course and treatment are much the same as for carcinoma.

# Section XXVI.

## SURGERY OF THE URINARY AND MALE GENITAL SYSTEMS.

### General Review of Symptoms: Their Localisation and Significance.

(A) **Pain.**—1. *Renal.*—Pain produced by a lesion of the kidney is felt in the back or front of the loin, or in both.

(*a*) Posterior renal pain is a persistent ache of varying severity felt high up in the lumbar region, in the small angular depression bounded by the twelfth rib and the outer border of the erector spinæ, and radiating forwards from this point through the loin. It is occasionally associated with hyperæsthesia of the skin in this neighbourhood.

(*b*) Anterior renal colic is referred to a point over the outer border of the rectus muscle a short distance above the level of the umbilicus. It usually indicates some disease of the pelvis of the kidney together with temporary blockage of the beginning of the ureter (the ureteral strait), as in stone and villous carcinoma of the pelvis, or kinking of the ureter in some cases of movable kidney.

2. *Ureteral colic* is produced by irregular spasmodic contractions of the muscular walls of the ureter. It is referred along a line on the anterior abdominal wall corresponding roughly on the surface with the anatomical course of the ureter, and radiates downwards along the distribution of the genito-crural nerve to the front of the thigh, to the testicle in the male, and to the labium in the female. The testicle is drawn upwards by contraction of the cremaster muscle, and for some hours or weeks afterwards may be exquisitely tender. The pain varies in severity from agonising paroxysms accompanied by vomiting, sweating, and collapse, associated with the passage of a calculus, to pain of moderate degree produced by the passage of blood-clot or tuberculous *débris* down the ureter.

3. *Vesical.*—A feeling of suprapubic discomfort indicates some disease of the bladder and, in a case of severe cystitis, may be exaggerated into a feeling of intense straining (strangury) during micturition. With this there is usually urgency.

Pain, at the termination of the act of micturition referred to the glans penis in the region of the frænum, is indicative of some trouble in the base of the bladder near the internal urinary meatus, *e.g.*, stone, the passage of tuberculous *débris* in the urine, or, more rarely, the seizure of processes of a villous growth by the internal sphincter.

4. *Prostatic.*—Prostatic disease is usually indicated by a feeling of fulness and weight, perhaps actual pain, in the perineum. Carcinoma of the gland in its later stages gives rise in addition to much trans-sacral pain, which is worse at nights, and may become diffuse and radiate downwards along the backs of the thighs.

5. *Urethral.*—An intense scalding and stinging sensation in the urethra during micturition is produced by any form of acute urethritis; it also occurs in phosphaturia, and may accompany the passage of gravel. When this is

associated with increased frequency, urgency, and strangury it will be found that the prostatic urethra and neck of the bladder are also infected.

(B) **Character of micturition.**—Much may be learnt by actually watching the patient pass his water. In cases of prostatic obstruction there is usually some hesitancy ; straining hinders rather than helps the act, which terminates in a characteristic dribble. The flow of urine may be intermittent. The stream has a diminished calibre, and, as there is little force of projection, may fall almost directly to the ground.

In stricture, on the other hand, a stream of small calibre is projected well beyond the patient, and straining is often essential for the initiation of the act.

(C) **Increased frequency of micturition.**—Increased frequency may be physiological or pathological.

1. Physiological frequency occurs in patients suffering from such conditions as diabetes or amyloid disease, or in cases of mental disturbance, when a large amount of urine is secreted by the kidneys and has to be got rid of by frequent actions of the bladder.

2. Pathological frequency is associated with some disease or irritability of the urinary tract itself. Usually indicative of bladder or prostatic disease, this is by no means always the case. Perhaps the only symptom which may draw attention to tuberculous disease of the kidney in its early stages is a slightly increased frequency, and, later, the disease often makes itself known by the attacks of increased frequency, pain, and strangury, which occur when a collection of tuberculous *débris* is discharged down the ureter.

In stone, the bladder irritability is more marked in the daytime when the patient is moving about. In prostatic cases the frequency is equally great, night and day, except for a period of immunity from 10 p.m. to 3 or 4 a.m. during the patient's first hours of recumbency.

(D) **Hæmaturia.**—It is usual to separate into three groups hæmorrhage arising in the urinary tract.

1. *Renal type.*—In this the blood is uniformly diffused throughout the urine, and the latter varies from a smoky to a bright red colour, depending upon the amount and the rapidity of the bleeding. If profuse, a long worm-like cast of the ureter may be passed.

2. *Vesical type.*—Here the first portions of the urine passed may be clear or only slightly tinged, whilst a few drops or more of pure blood may be voided at the termination of the act. Hæmaturia in cases of adenomata of the prostate is of this type, because the bleeding arises, not from the prostatic plexus, but from small varicose veins of the mucous membrane of the bladder neck.

3. *Urethral type.*—The passage of a few drops of pure blood or highly-tinged urine at the commencement of micturition characterises this type. It occurs in cases of ruptured urethra and occasionally in very acute urethritis.

The passage of a ureteral clot is diagnostic of renal or ureteral bleeding, but, with this exception, little or no reliance can be placed on these facts in diagnosis. The cystoscope alone can identify with accuracy the source of the hæmorrhage.

(E) **Pyuria.**—The pus derived from infections, such as *bacillus coli*, of the pelvis of the kidney is usually finely diffused throughout the urine and gives it a hazy or milky appearance, the minute particles taking a long time to settle. In pyuria of bladder origin, on the other hand, there is usually an admixture of much thick, ropy mucus, and the urine, if allowed to stand, quickly clears, the pus collecting as a heavy granular mass at the bottom of the specimen

glass. An acid pyuria occurs in pure infections by *bacillus coli*, the gonococcus, or the tubercle bacillus. Staphylococci produce an alkaline decomposition of the urine, whilst streptococci and proteus are usually found in neutral or slightly acid specimens.

## Methods of Physical Examination.

(A) **Abdominal examination.**—On bimanual palpation a kidney swelling has the following characteristics. It is a swelling, often of a reniform shape, which lies deep in the loin, and, if of any size, it is usually possible to *ballotte* it between the hands placed in front of and behind the loin of the affected side. It moves freely on respiration and has a certain amount of side-to-side mobility. A small tumour has intestine in front of it and is resonant, a large one is dull; except in cases of large tumours arising in the upper pole of the kidney, they all have a band of resonance separating them from the liver. On the right side, as the kidney enlarges downwards and outwards, the hepatic flexure of the colon, originally in front of its lower pole, tends to slip off the inner side of the swelling altogether. On the left side the anatomical relations are such that the descending colon passes downwards over the most prominent portion of the enlarged kidney. This portion of the gut is usually small and contracted, and can be seen and felt better than it can be identified by percussion.

A renal swelling on the right side has to be distinguished from a distended gall-bladder, a Riedel's lobe of the liver, or a hydatid cyst, from a pseudo-cyst of the pancreas, an ovarian cyst, a malignant mass in the colon, and on the left side from an enlarged spleen.

A distended gall-bladder may be of pyriform shape, and conveys an impression of being situated more anteriorly in the abdominal cavity. Unless of very large size, it cannot be pressed back into the loin, and its dulness is continuous with that of the liver.

A pancreatic swelling is more medianly situated, and, like other retro-peritoneal tumours, is immobile. Carcinoma of the colon usually has much greater lateral mobility, and an ovarian cyst, whilst retaining considerable lateral and downward mobility, has its upward excursion abruptly limited by its pedicle.

On the left side the shape, the superficial position, the notching of the sharp anterior border, and the enlargement downwards and inwards towards the umbilicus of a splenic swelling are very characteristic. In this connexion difficulty usually arises when the enlarged spleen has prolapsed and fallen backwards into the loin. When this has occurred, the wedge-shaped anterior margin, rather than rounded surface, and the extreme lateral position of the tumour are usually sufficient for accurate diagnosis.

A distended bladder is very evident as an oval, elastic swelling, dull on percussion, rising from the pubes towards the umbilicus. It can be readily seen and felt, and, if the viscus cannot be grasped between the hands placed on either side of the recti, it is better to neglect doubtful percussion signs and to assume that no material distension is present.

(B) **Examination of a scrotal swelling.**—After a preliminary general survey of the scrotal condition and overlying skin the neck of the scrotum is grasped, and with the patient in the erect position he is made to cough. In this way it can be determined whether the swelling is one of purely scrotal origin, whether it is one which has passed down into the scrotum from above, or whether a testicular swelling is complicated by an inguinal hernia, a varicocele, or some other condition.

A definite decision on this point having been arrived at, the patient is made to assume a recumbent position and the following facts elicited :—

Is the swelling in the main a fluid or a solid one ?

(*a*) If fluid.

What is the relation of the testicle to the swelling as determined by palpation and transillumination ? In those cases in which distension of the tunica or processus vaginalis has occurred the testicle will appear to be within the swelling, lying usually in its lower posterior portion. In encysted hydrocele of the epididymis (spermatocele) or cord, on the other hand, a globular collection of fluid will be found situated above the testicle, and the latter can be identified apart from the main swelling.

Transillumination, although a very unreliable test for fluid, is invaluable for this investigation.

(*b*) If solid.

1. *The anatomical situation.*—Is the swelling one which has affected the body or the epididymis, or is it impossible to distinguish between these two portions of the testicle ? Although new growths almost invariably arise within the body or the mediastinum testis, they usually infiltrate the tissues of the epididymis so rapidly that clinically it is impossible to differentiate the two anatomical portions of testicle from one another in the hard uniform mass which is found.

2. *The presence or absence of a secondary hydrocele.*—This is best identified by grasping the posterior aspect of the scrotum with the fingers and palm of one hand in such a way that the swelling is pushed forward and the skin made tense over it, whilst the forefinger of the other hand lightly touches the anterior aspect of the swelling. If fluid is present, the feeling of elasticity conveyed to the examining finger is very characteristic and cannot be mistaken. In the event of there being more than a drachm or two of fluid in the vaginal sac, it is wise to draw this off with a fine trocar and cannula before venturing to offer an opinion on the condition of the affected testicle.

In malignant disease this fluid may be blood-stained, or may prove to be an actual hæmatocele.

3. *The condition of the vas deferens and the lymphatics of the cord.*—In tuberculous epididymitis it is usual to find thickening of the vas in quite the early stages of the disease, whilst, even in advanced cases, it is possible to identify the other individual constituents of the cord and to roll them one by one between the finger and thumb.

When the lymphatics of the cord are clinically involved, as in malignant disease of the testicle or in urethral epididymitis, the constituents of the cord are matted together into a uniformly hard, rod-like structure. It is impossible to identify even the vas itself. The lymphatic vessels of the cord pass directly upwards into the abdomen and drain into the lumbar glands situated immediately below the origin of the renal vessels, and it is usually only when the skin of the scrotum becomes actually infiltrated that the superficial glands of the groin become infected.

(C) **Rectal examination.**—The genu-pectoral position should always be utilised when a rectal examination is made with a view to investigating the condition of the lower urinary tract. When the examining finger has been passed through the anus to just beyond the proximal interphalangeal joint the prostate will be felt bulging into the anterior rectal wall. It is a very firm, rounded body, showing a slight indication of a median longitudinal groove and two well-marked gutters at its lateral borders. The depth of these gutters is the best criterion of the amount of projection of the gland into the

rectum. Under normal circumstances its strong fascial connexions make the prostate a fixed organ, at the same time allowing a certain amount of spring on firm pressure, and it is only when it is the seat of large masses of encapsulated adenomata that it becomes actually movable in the ordinary sense of the term. As the finger passes onwards it can be hooked into the concavity of what appears to be the upper border of the prostate; in reality, this is the upper limit of the vesiculæ seminales (see diagram).

Unless indurated by disease, it is impossible to outline definitely the vesicles apart from the prostate. Immediately above this concave border the finger comes into contact with the soft resistance of the bladder base, and it is here, where the fibrous sheath of the prostate is deficient, that the first signs of infiltration of a malignant growth in the gland will be found.

If the termination of the ureter contains an impacted stone, or if it is surrounded by the periureteritis of tuberculous disease, it will be readily felt through the anterior rectal wall. A marked groove separating it from the concave upper border of the "prostate" distinguishes it clinically from an indurated vesicle.

In the female a thickened ureter can be readily felt on bimanual examination passing inwards and slightly forwards above the lateral vaginal fornix.

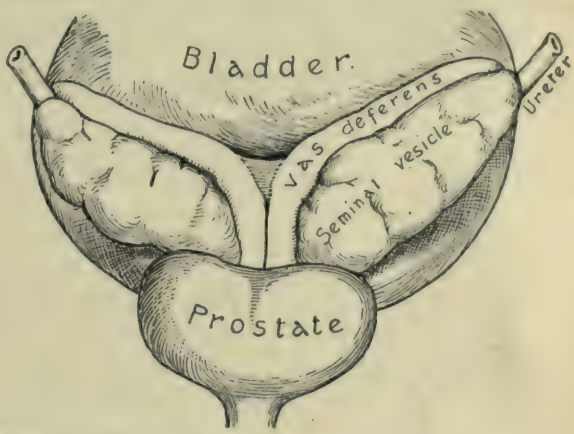



FIG. 412.—Diagram of structures in anatomical relation with the anterior wall of the rectum.

(D) **Cystoscopic examination.**—It may be said at once that the cystoscope is the only key to accurate urinary diagnosis. Without it the most careful consideration of all the symptoms and physical signs available may fail to reveal the site of the lesion, and often lead to a useless exploratory operation. The bladder having been distended with 8 or 10 ounces of boracic lotion, the examination, which can be made either after the injection into the urethra of 2 drachms of a 5 per cent. solution of novocaine or under a general anæsthetic, should be carried out in a systematic manner. After a preliminary general survey of the bladder wall has been made by slowly rotating the instrument in a complete circle the interureteric bar is identified, and then, by turning the indicating knob of the cystoscope to 4.30 and 7.30 on an imaginary watch dial, the openings of the two ureters are found.

The character of the openings, of the surrounding mucous membrane and the efflux should be noted. In this way alone can a diagnosis of unilateral tuberculosis of the kidneys be made with any certainty and, in a case of renal pyuria, the true source of the pus discovered.

A good example of the usefulness of this instrument is afforded by some cases of papillomata of the bladder. In the event of one of these growths arising from the bladder wall in the neighbourhood of a ureteric orifice, a very common situation, the symptoms complained of are:—

1. Painless hæmaturia, perhaps of uncertain type.

2. Post-renal pain from urinary stasis in the pelvis of the kidney of the affected side.

A consideration of these symptoms alone, with perhaps the use of a segregator which will show a unilateral hæmaturia, can only lead to an erroneous conclusion.

(E) **Urethral examination.**—Examination of the urethra can be carried out by palpation, by bougie, and by the use of the direct vision endoscope. A stone impacted in some portion of the urethra, or a hard " cartilaginous " stricture in the perineum, are readily felt. Acorn-headed bougies and the endoscope will reveal accurately the site, the calibre, and the condition of the surrounding mucous membrane in cases of stricture. The latter instrument may clear up the diagnosis in cases of urethral hæmorrhage of doubtful origin, and is employed in the direct application of strong silver solutions to the localised lesions of the mucous membrane occasionally found in cases of long-standing gleets.

## Estimation of Renal Efficiency.

Before embarking upon any surgical operation other than an emergency one it is essential to obtain as accurate an estimate as possible of the work the kidneys are capable of performing. Any neglect of this very obvious precaution will most certainly lead to disaster sooner or later.

Where it is not proposed to remove or seriously to embarrass any of the available secreting substance of the kidney, as in the removal of a stone, or where the operation is being performed upon some part of the body outside the urinary system, an examination of a twenty-four hours specimen of urine of known quantity will suffice. The patient is kept upon a diet of known nitrogenous value during this period of observation.

When, however, information as to the capacity for work of one kidney in particular is required, the urine of this side will have to be collected separately.

This can be carried out by ureteral catheterisation or by the use of a segregator. Of these two methods the former is undoubtedly the more reliable, as it is extremely difficult to effect a true separation of the two halves of the bladder by any form of separator in use at the present time. Again, this investigation is most frequently required in pyuria, and it is impossible in a case of unilateral renal infection, even after the most thorough preliminary washing out of the bladder, to prevent fouling by the vesical mucous membrane of the urine secreted by the sound kidney. The objections to the use of ureteral catheters are :—.

1. Unless they fit the ureters with fair accuracy some urine may leak past them into the bladder, and the amount secreted by a given kidney be placed too low in consequence.

2. They may so depress the function of the kidney that the urine secreted may be considerably lessened in amount or even suppressed entirely for the time being. This error may be eliminated by neglecting the urine collected for the first half-hour after insertion.

3. Infection of the sound kidney. This risk is not a serious one if the operation be gently and deftly carried out, and it is fair to say that any risk incurred is far outweighed by the importance of the information thus acquired.

Catheterisation of one ureter only may be all that is required, as the urine from the other kidney can be secured by an ordinary catheter passed into the bladder at one and the same time. In a case of suspected unilateral

tuberculosis, after a preliminary cystoscopic examination, the catheter will be passed into the ureter of the apparently sound kidney to prove its immunity; in calculous pyo-nephrosis the urine from the diseased kidney will be collected. In the latter instance it will be decided whether the work done by the affected kidney is so material as to negative anything more radical than

FIG. 413.—An X-ray photograph of a normal kidney showing the calyces, pelvis and upper portion of the ureter outlined by the injection of a solution of collargol.

a drainage operation, or whether, being practically negligible, the more satisfactory operation of primary nephrectomy, with its much shorter period of convalescence, should be carried out.

**Tests of renal efficiency.**—(1) *Examination of urine.*—A systematic microscopical and chemical examination of the urine under consideration should be carried out on several occasions. Of the information thus obtained, the specific gravity, the amount of albumen, and the total amount of urea passed

in twenty-four hours are probably of the greatest importance. If in a patient taking an ordinary full diet, and confined to bed, the specific gravity remains persistently below 1008, or if the total amount of the urea output per diem, as estimated by Folin's method, is constantly below 15 grammes, in the absence of exceptional circumstances the case should be regarded as one unsuitable for surgical operation.

(2) *Colour test.*—If 1 drachm of a 4 per cent. solution of indigo-carmine in normal saline is injected subcutaneously, an intense blue coloration should appear in the urine within fifteen to twenty minutes. If this is delayed beyond half an hour, or if the colour when it appears is only of a greenish tinge, the condition of the kidney under consideration should be regarded with grave suspicion.

The power of the kidney to split up phloridzin and excrete part of it as sugar, when a 1 per cent. solution is injected into the general circulation, is occasionally made use of as a test of renal efficiency, and various other methods are sometimes employed. But in the present state of our knowledge the interpretation of the results obtained is so uncertain, the analysis necessary so complicated and prolonged, that these methods cannot be regarded as of much importance in ordinary clinical practice. Indeed, no one test can be regarded as completely reliable in itself, but if all are taken into consideration and due regard paid to the clinical aspect of the case, it is usually possible to arrive at a correct decision.

*Pyelo-radiography* is the application of Röntgen-ray photography to the study of the contour and size of the renal pelvis. Briefly, the technique is as follows :—

A ureteral catheter, preferably one which is opaque to X-rays, is first passed in the ordinary way into the pelvis of the kidney. A solution of some chemical, opaque to X-rays, is allowed to run by gravity into the pelvis, this being discontinued immediately the patient begins to complain of a feeling of backache. A photograph is then taken with as little delay as possible, the solution allowed to drain away from the kidney and the catheter withdrawn.

The capacity of the normal renal pelvis is usually about 8 or 10 cc. A 10 per cent. solution of the organic silver salt, collargol, is most commonly employed, and although it rapidly diffuses through the renal parenchyma and produces a transient albuminuria for a few days, and some desquamation of the epithelium lining the renal pelvis, it does not appear to cause any permanent damage to the epithelium of the renal tubules.

This method is still in its infancy, but has already proved of considerable service in the diagnosis of intermitting hydro-nephrosis and congenital anomalies of the kidney and ureter, and in the differential diagnosis of abdominal swellings of doubtful origin.



## Congenital Anomalies.

1. **The kidney and ureter.**—The absence of one kidney from its usual position in the loin may be associated with one of the following conditions :—

(*a*) *Horse-shoe kidney.*—A horse-shoe kidney is a somewhat irregular, crescentic-shaped mass of renal tissue, which has resulted from the fusion of the two kidneys, their lower poles being united across the middle line by a bridge of tissue of varying width. The compound organ usually lies across the spine in a median position, with the concavity of the horse-shoe directed upwards. Each horn is drained by a separate ureter, which runs downwards

in a groove on the anterior aspect of the kidney, and often shows dichotomous branching of its upper end.

(*b*) *Congenital misplacement of the kidney.*—This is a condition quite distinct from the acquired displacement and mobility, which are seen in cases of movable kidney (see p. 1040). The organ has been actually developed in its abnormal situation, and is often more fixed than usual. A common position in which to find it is the iliac fossa, or even lower down on the anterior aspect of the sacro-iliac joint.

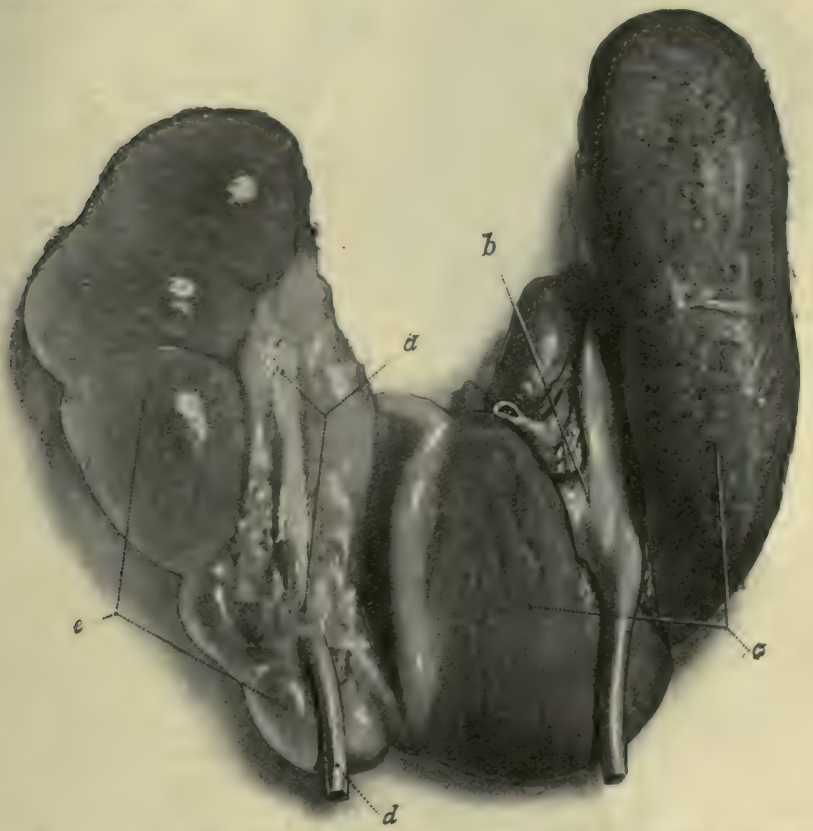



FIG. 414.—Front view of a horse-shoe kidney, the right half of which consists of a hydro-nephrotic sac. *a*, Fibrous cord representing upper portion of right ureter. *b*, Pelvis of left ureter. *c*, Two lobes of left portion of kidney partially separated by a deep furrow. *d*, Pervious portion of right ureter. *e*, Hydro-nephrotic right half of kidney. (St. Bartholomew's Hospital Museum.)

(*c*) *Congenital absence or atrophy of the kidney.*—One kidney may be absent entirely or exist only as a small knot of fibrous tissue, occupying the usual position in the loin and connected with the bladder by a thin fibrous cord representing the ureter. A large, hypertrophied kidney is usually present on the other side (Fig. 415).

A congenitally misplaced and a horse-shoe kidney are of practical interest in the differential diagnosis of solid tumours of the abdomen without symptoms, and, although a rare condition, the possibility of the existence of one kidney only is of the greatest importance. Under no circumstances can the idea o

nephrectomy be entertained, unless the presence of a second and healthy kidney has been definitely established.

The commonest abnormality of the ureter is a double condition on one or both sides. The two ureters draining one kidney may join together a short distance below their origin, or not until they are within an inch or so of the bladder; occasionally they remain separate throughout their entire extent, and communicate with the bladder by two distinct openings in close proximity to one another. A congenital stricture or valve, leading to hydronephrosis of part or the whole of the kidney, may exist at the pelvo-ureteral junction or at the vesical inlet.

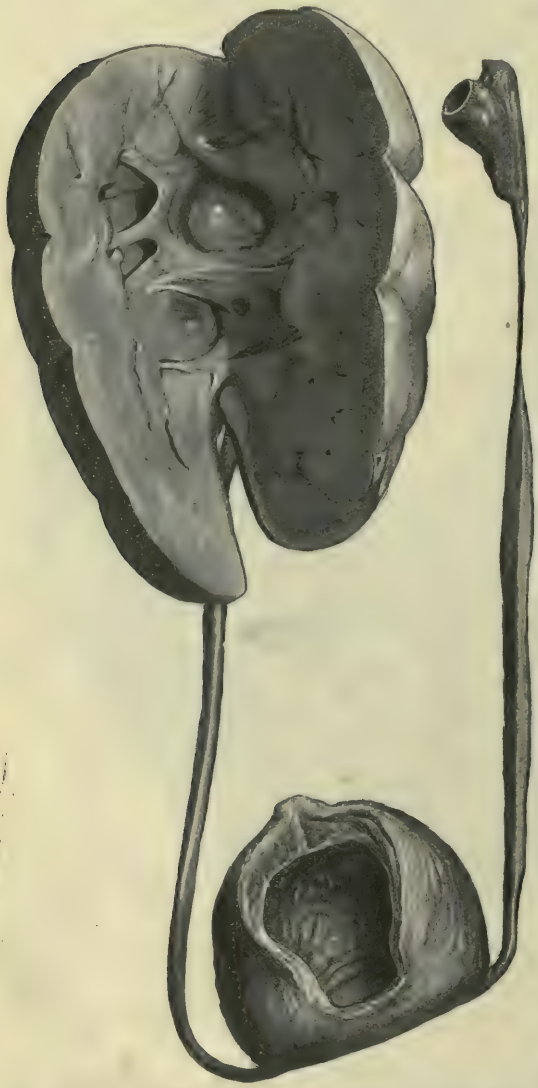


FIG. 415.—Congenital absence of one kidney with compensatory hypertrophy of the opposite organ. (St. Bartholomew's Hospital Museum.)

Ballooning of the lower end of the ureter, which is due to a congenital stricture of the ureteric orifice, is almost always associated with a double ureter on the affected side. Cystoscopic examination in these cases shows a globular swelling on the base of the bladder, which alternately distends with each ureteric efflux and then slowly collapses, the ureteric opening being situated on the summit of the sac. The opening of the second ureter is usually concealed from view. This is a condition quite distinct from prolapse of the ureter, which occasionally follows the impaction of a stone in its lower end.

Any evidence of imperfect development of the kidney or ureter, whether it be merely a persistence of fœtal lobulation or one of the more gross changes, noted during the course of a kidney operation, should be a practical warning to the surgeon to be on the look-out for the presence of abnormal renal vessels. Apart from variations in the number and arrangement of the vessels in the hilum of the kidney, the commonest

abnormality is an aberrant artery having a separate origin from the aorta, and entering one or other renal pole, usually the lower, on its inner or front aspect.

2. **The bladder.—Ectopia vesicæ.**—In this condition there is complete absence of the inferior surface of the bladder, and, owing to a congenital failure of union across the middle line of the two halves of the lower anterior abdominal wall, the mucous lining of the postero-superior aspect of the bladder is open to the air and bulges forwards above the os pubis.

The exposed mucous membrane has a characteristic dull red, velvety appearance, and is kept constantly wet by urine, which can be seen issuing from the openings of the ureters in little trickles. The surrounding skin is red and often excoriated, and is connected with the bladder wall by a broad band of fibrous tissue. The pubic arch may be deficient in the middle line. Extroversion of the bladder may occur in either sex, but it is commoner in males, and in them the penis is often small and deformed. A groove on the dorsal surface of the latter represents the unclosed urethra (*epispadias*), and can be traced upwards into the lowest portion of the bladder surface.

These patients, if untreated, rarely live much beyond twenty-one years, and often show a condition of bilateral hydro-nephrosis on post-mortem examination.

*Treatment.*—If the renal function is not grossly impaired, the best treatment is to excise the whole bladder with the exception of a small oval portion of the base carrying the two ureters. This small segment is mobilised, the ureter and inferior vesical arteries being carefully preserved as a pedicle, and turned upwards and to the left.

An incision is then made into the pelvic colon through its anterior muscular band, and by retracting the margins of this laterally an oval deficiency is created in the wall of the bowel into which the small piece of bladder wall can be placed and accurately sutured in position (Maydl's operation).

The gap in the anterior abdominal wall is then made good as far as possible by mobilising portions of the recti muscles. Owing to the separation of the two portions of the pubic arch which is usually present, this often proves the most difficult part of a severe, but not necessarily dangerous, operation. The after history of these patients shows that a fair proportion of them remain free from an ascending ureteric infection and live useful and comfortable lives for a considerable number of years, the anal sphincters acquiring surprisingly good control and preventing leakage of urine.

Formerly two other methods for the treatment of ectopia vesicæ were adopted :—

(*a*) Attempts to repair the deficiency in the inferior wall of the bladder by various complicated flap operations.

(*b*) Diversion of the course of the urine by bilateral nephrostomy, followed by removal of the bladder.

The results of these operations were not encouraging, and, even if successful, the patient was compelled to wear a cumbersome special apparatus and a portable urinal with all its attendant discomforts.

**Patent urachus.**—The urachus is the fibrous cord which passes from the apex of the bladder to the umbilicus, and lies in the extraperitoneal fatty tissue. It is derived from the intra-abdominal part of the allantois, the caudal portion of which remains as the adult bladder. In some cases complete occlusion does not occur, and a fistulous track results which discharges urine at the umbilicus. This condition is often associated with some congenital obstruction of the urethra, which should be remedied first, and if the

fistula still persists it should be dissected out completely by means of a long median abdominal incision.

If the lower portion only of the urachus remains patent, it may dilate into a pouch communicating with the bladder near its apex, and a stone may form in the diverticulum. Occasionally an oval cystic swelling, completely shut off from the bladder, develops in this situation.

3. **Penis and urethra.—Hypospadias** is a congenital defect, in which, owing to imperfect developmental infolding of the anterior portion of the urethra, the floor of the latter is deficient and urine escapes from an opening on the under-surface of the penis. The aperture is in the middle line, usually in the neighbourhood of the frænum, but may be situated in any portion of the penis, or in the perineum immediately behind the scrotum. The penis is small, shows a dimple in the normal position of the meatus, and is bent abruptly downwards by a strong fibrous band connecting it with the scrotum. The prepuce is often of a curious hooded shape, and overhangs the glans penis from above. The condition is often associated with imperfect descent of the testicles and mal-development of the scrotum. It produces two unfortunate results :—

(*a*) Difficulty in coitus, owing either to the impossibility of introducing the penis into the vagina or to the spilling of the semen on emission.

(*b*) An eczematous condition of the skin of the scrotum and inner aspect of the thighs, due to frequent fouling with urine.

*Treatment.*—Many ingenious flap operations have been devised and successfully carried out for the cure of this condition (*see special works on operative surgery*). Several operations are usually necessary to effect a complete closure, and should be performed, if possible, between the ages of three and five years.

**Epispadias** is a curious congenital lesion, in which the urethra opens upon the dorsal surface of a small deformed penis. The condition is very rare, and no satisfactory embryological explanation of its occurrence is forthcoming.

For *imperfect descent of the testicle*, see p. 1108.

## Traumatism.

**Gunshot wounds involving the urinary tract.**—The treatment of gunshot wounds is carried out much on the lines indicated below for injuries met with in civilian practice. It should be combined with clean excision of all damaged tissue, removal of the foreign body where possible, and primary or secondary suture of the wound in the abdominal parietes as circumstances permit. (For details, *see special works on war surgery.*)

**Injuries of the kidney.**—The kidney may suffer as the result of a stab, or may be injured by a fall or severe blow on the loin, the common accident being a crush between two opposing railway buffers. It is to the latter type of accident that the following description mainly applies. The injury consists of one or more lacerated tears, mainly in a transverse direction, and the rupture may be complete or incomplete.

If complete, one pole may be torn off or the kidney may be almost completely disintegrated, whilst an incomplete rupture varies in severity from a mere subcapsular laceration to a tear which includes the true capsule or extends into one of the calyces. Profuse hæmorrhage occurs into the kidney, and if the capsule is ruptured a large collection of blood-clot, limited and checked to a certain extent by an uninjured peritoneum, forms in the perinephric tissues. Blood may track downwards along the course of the spermatic

vessels and produce much staining of the skin of the inguinal and scrotal regions. The kidney itself may be enlarged appreciably, and blood flowing into the renal pelvis may be discharged down the ureter. If the peritoneum is also torn, blood is poured out freely into the peritoneal cavity. If the pelvis or upper end of the ureter has been injured, or if a tear involving the true capsule communicates with one of the calyces, there will be extravasation of urine. Anuria may be caused by an injury to both kidneys, but is said to occur occasionally in unilateral cases, when the pelvis of the affected kidney is blocked by blood-clot and the secretion of the opposite organ suppressed by reflex inhibition. Suppuration may follow, and is almost certain to supervene in those cases in which there has been a leakage of urine. The pus may be confined to the kidney, producing a pyo-nephrosis, but is more likely to give rise to a large perinephric abscess or a general septic peritonitis.

After a severe accident of this kind the patient usually suffers from profound shock for a few hours, sometimes accompanied by persistent vomiting. The signs of severe internal hæmorrhage, profuse hæmaturia, and the presence of an indefinite boggy swelling in the loin, taken in conjunction with the history and the external marks of violence, are usually sufficient to establish a correct diagnosis. If the peritoneum has been torn or any other abdominal viscus, such as the spleen or liver, has been injured also, free fluid will be detected in the abdominal cavity.

*Treatment.*—The slighter cases do not require any active surgical treatment other than the adoption of the usual methods for combating shock. If the bladder becomes distended with clot, it should be emptied by an evacuator. The signs of severe progressive hæmorrhage, however, whether it be in the form of a continuous profuse hæmaturia, a gradually-increasing tumour in the loin, or a considerable amount of fluid in the peritoneal cavity, demand immediate exploration. It is advisable also to operate on cases of anuria when there is no reason to suppose both kidneys are involved. In the absence of signs of free fluid in the abdominal cavity the affected kidney should be explored from the loin. In the case of small tears it may be possible to suture the wound, but if there is extensive laceration of the kidney or any injury of its vessels nephrectomy should be performed at once. If there are signs of intraperitoneal hæmorrhage, the abdomen should be opened by a large incision through the outer border of the rectus, a tear in the liver sutured or a ruptured spleen excised, and then the renal condition dealt with as before, after opening up the tear in the overlying peritoneum. Drainage for at least forty-eight hours should be established by a stab cut in the loin.

**Injuries of the ureter.**—The upper end of the ureter may be torn by the same accident which ruptures the kidney, and the former, if untreated, results in a perinephric abscess and a persistent urinary fistula. The majority of injuries to the ureter occur during difficult abdomino-pelvic operations. This is not so liable to happen in abdomino-perineal excision of the rectum or complete extirpation of the uterus for carcinoma, because in these procedures the ureters are identified and isolated as a preliminary measure; a ureteral fistula developing some days after one of these operations is due to post-operative sloughing following too extensive stripping of the ureter from its vascular sheath. Section of the ureter occurs most frequently in operations for the removal of parovarian cysts, or subperitoneal fibroids which have burrowed widely in the tissues of the broad ligament. In these cases the ureter is often much displaced, and may be stretched over the surface of the tumour.

If the ureter is divided close to the bladder the latter is mobilised, and

the distal end of the ureter having been ligatured, its proximal end is implanted into the fundus of the bladder. Often it happens that before the unfortunate accident is discovered a large section of the ureter has been removed with the tumour. In these circumstances, the surgeon having assured himself by palpation that a second and apparently normal kidney is present, the safest and wisest course is to ligature both ends of the divided tube.

Within four or five days a small painless, hydro-nephrotic tumour may, or may not, be palpable in the loin ; this does not cause symptoms and usually disappears in the course of two or three months. If it should become infected, an unlikely event, the kidney must be removed.

**Rupture of the bladder.**—The neck of the bladder may be torn in fractures of the pelvis which involve and cause some displacement of the pubic arch. A full bladder may also be ruptured by direct violence applied to the lower abdomen, the perineal or sacral regions ; a common example of this type of accident is a kick in the abdomen during a drunken brawl, when the bladder is likely to be distended. The tear may be limited to the peritoneum-covered surface of the bladder, or may be confined entirely to the uncovered inferior surface, the former being the commoner.

Blood-stained urine at once escapes, and in the extraperitoneal cases forms a tumour in the suprapubic space, which, if not operated upon, suppurates and tracks widely in the loose tissues of the pelvis. In similar circumstances the intraperitoneal cases are rapidly fatal from septic peritonitis.

If the patient is seen immediately after the accident the diagnosis of a ruptured bladder may be exceedingly difficult, but should always be suspected if a severe injury in this region is followed by considerable pain and shock, and the passage of small amounts of blood-stained urine.

In the extraperitoneal cases an increasing boggy swelling will gradually form above the pubes, and in intraperitoneal rupture evidence of free fluid in the peritoneal cavity may be detected. The most characteristic feature is the failure to obtain more than a few drops of blood-stained urine on passing a catheter. Provided that, if necessary, the patient is prepared to undergo an immediate operation, the diagnosis can be confirmed by injecting a known quantity of fluid into the bladder and noting that only a small amount of this can be withdrawn by the catheter.

*Treatment.*—The condition should be treated by immediate operation. The bladder is exposed extraperitoneally by a median suprapubic incision and a rent in its inferior wall or neck partially sutured with chromicised catgut, a half-inch drainage tube being inserted into the bladder through a convenient portion of the tear. If the extraperitoneal portion of the viscus is found to be intact, the incision is prolonged upwards and the general peritoneal cavity opened. The wound in the bladder having been found, it is closed by sutures of chromicised catgut taking up all the coats except the mucous membrane and the line of union buried by Lembert sutures of fine silk. A catheter is then passed and the efficacy of the suturing verified by injecting some boracic lotion into the bladder. If the test proves satisfactory, the peritoneal cavity is sponged dry and the abdominal wound closed, a small drain being inserted into the recto-vesical pouch. A catheter should be tied into the bladder and retained for about a week until all danger of leakage is over.

**Injuries of the penis.**—*Rupture and fracture* of the penis with much extravasation of blood, also dislocation of the penis into the scrotum, have been produced by a squeeze or crush.

*Ligature round the penis.*—A piece of string is sometimes tied round the

penis by children, either in play or to prevent themselves being punished for wetting the bed. Great swelling in front of the constriction ensues, and if the cause is not recognised and removed the string will soon cut deeply into the penis, and the urethra may be divided.

The penis, under sexual excitement, may be thrust through some unyielding ring which is difficult to divide, and the swelling may end in gangrene.

*Rupture of the frænum.*—Quite severe hæmorrhage may follow when the artery is only partly torn across; when completely divided the hæmorrhage usually ceases, but it is safer to ligature the proximal end.

*Mutilation of the genitals.* Injuries of this class are occasioned by sexual excitement, melancholia, and religious mania; also mutilation is still carried out in some parts of the East in the making of eunuchs. If the penis is cut off whilst erect there is grave hæmorrhage. After part of the penis has been cut off an obstinate stricture develops at the end of the stump, or the urine from the retracted urethra dribbles over the scrotum. If, as in making eunuchs, the genitals are pulled forwards and then cut away in front of the os pubis, the constrictor urethræ is impaired, and there may be incontinence. *Treatment.*—Repair as after amputation of the penis, the urethra being isolated and fixed in the perineum.

**Traumatic rupture of the urethra.**—Rupture of the urethra usually occurs at the bulbo-membranous junction, and is caused by a fall astride a beam or a violent kick in the perineum, or is secondary to a fractured pelvis. The rupture may be complete or incomplete.

There is usually some bruising and swelling visible in the perineum, and blood can often be seen oozing from the external meatus. In cases of partial rupture some blood-stained urine may be passed, but if the urethra is completely torn across micturition is impossible. In the latter case any attempt to empty the bladder naturally will result in extensive extravasation of blood-stained urine into the superficial perineal space, and thence upwards over the scrotum, the penis, and anterior abdominal wall (see p. 1102).

*Treatment.*—The patient is at once given a general anæsthetic, and an attempt made to pass a well-lubricated silk-web catheter, No. 8 or 10 E. If the urethra is only partially torn, this may be successful, and urine is drawn off. The catheter is then tied in and left in position for seven or eight days. A small median incision is made in the perineum down to the urethra over the site of the bruising for drainage purposes.

If a catheter cannot be made to enter the bladder a metal sound is passed down to the site of the obstruction and its point cut down upon by a median perineal incision. A careful search is then made for the proximal end of the urethra, and if it can be identified, a silk-web catheter is passed from the meatus and its point guided onwards into the bladder from the perineum. An attempt is made to suture the two ends of the urethra around the catheter with fine catgut sutures, the catheter tied in, and the perineal wound left open and lightly packed with gauze.

If prolonged search fails to reveal the proximal end of the urethra, the bladder is opened above the pubes, a sound passed into the internal meatus and out through the perineal wound, and the operation completed as before.

Rupture of the urethra may be followed by a most intractable traumatic stricture if very prolonged after-treatment by bougies is not adopted (see p. 1100).

**Injuries of the testis.—A hæmatocele** is a collection of blood in the tunica vaginalis. It may follow any severe injury to the scrotum, but more often

is the result of hæmorrhage into the sac of a pre-existing hydrocele after tapping.

The hæmorrhage may be derived from a small vein in the sac, which has been perforated by the trocar, or from an actual wound of the testicle itself. A punctured wound of the latter is a serious accident. Its occurrence gives rise to sudden severe pain, and, owing to the pressure of the effused blood within the unyielding tunica albuginea, is often followed by necrosis of the organ. The sudden relief of pressure which occurs after tapping a large tense hydrocele may also occasion a certain amount of hæmorrhage into the sac from a general capillary oozing.

A hæmatocele occasionally follows the operation of radical cure of an inguinal hernia, if recurrent hæmorrhage takes place and the distal end of a congenital sac has not been closed by ligature. If it follows the tapping of a hydrocele, within a few hours the affected side of the scrotum swells up and becomes very tense and painful. The overlying skin is reddened and œdematous, and the temperature may rise as high as 101°, but the condition very rarely suppurates. Within a few days a dark blue discoloration of the scrotum appears.

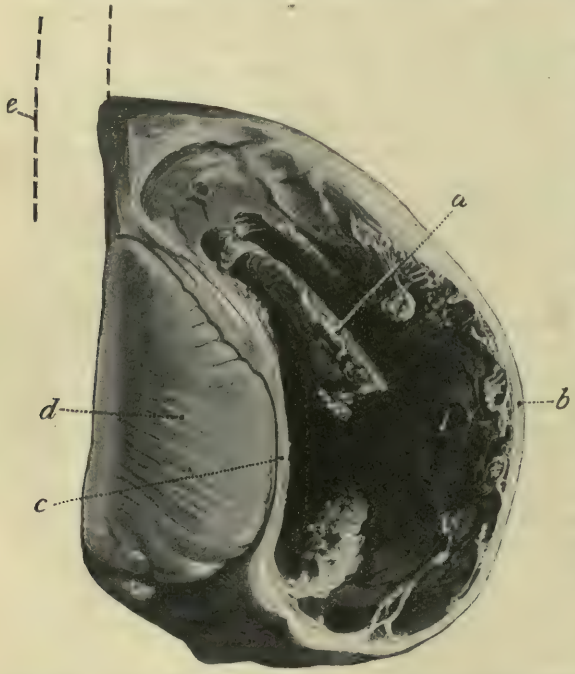



FIG. 416.—Hæmatocele. *a*, Blood clot. *b*, Parietal layer of tunica vaginalis. *c*, Visceral layer of tunica vaginalis. *d*, Body of testicle. *e*, Position of cord. (St. Bartholomew's Hospital Museum.)

If a hæmatocele is allowed to persist, much thickening of the sac due to fibrosis, and in some instances to the deposit of layers of fibrin upon its inner aspect in addition, occurs, and the testicle atrophies gradually from pressure.

*Treatment.*—An incision should be made over the swelling, the blood-clot turned out, and the operation completed as for the radical cure of hydrocele.

## The Mechanical Back-pressure Effects of Obstruction to the Urinary Outflow.

In addition to the thickening and dilatation which occur in the wall of the urethra proximal to the obstruction, the mechanical changes behind a fibrous stricture of the urethra or an enlarged prostate may be classified as follows :—

(A) **Changes in the bladder.**—The first change to occur is a general thickening of all the muscular coats, the bladder seeking to overcome the urethral

obstruction by a compensatory hypertrophy, which enables it to exert the increased force necessary to expel the urine. The curved interureteric bar stands out prominently, and the interior of the viscus shows a well-marked trabeculated appearance. These trabeculæ lie beneath the mucous membrane, and are thickened bundles of the oblique fibres composing the inner muscular coat, which have shared in the general hypertrophy. Although arranged in the main transversely, these rounded bars of muscle or fasciculi extend in various directions and branch and interlace in the most intricate manner.

Between the individual fasciculi are deep grooves lined by mucous membrane, and in extreme cases a complete hernia of the mucous lining may occur between the muscular bundles and result in the formation of a pouch or sacculus.

These sacculi vary much in size, but, however capacious they may become, they always communicate with the cavity of the bladder by a narrow mouth. This appearance of trabeculation is not confined to cases of urethral obstruction; it is occasionally very marked in cases of prolonged cystitis, in young women afflicted with increased frequency of micturition, and in some organic nervous lesions, such as tabes dorsalis. In the latter the fasciculi are flatter and more sickle-shaped, and show finer branchings and ramifications.

After some time the bladder begins to dilate and become pouched, and, in an untreated case, the balance between obstruction and hypertrophy breaks down and complete atony ensues. The muscular coat atrophies, and the capacity of the organ may increase to three or four pints, its walls thinning out to the thickness and durability of moist brown paper.

(B) **Changes in the ureter.**—After a short period of muscular hypertrophy compensation breaks down, and the ureters become dilated and pouched. In the final stages their diameter may equal or even exceed that of a piece of small intestine, although this extreme condition is usually only seen in cases in which the obstruction is situated in the ureter itself, as in impacted ureteral calculus. The ureter increases in length, and may become very tortuous.

In ordinary circumstances no regurgitation of fluid, and therefore no direct transmission of pressure from the hypertrophied bladder, is possible, owing to the valvular arrangement of the ureteric openings. The changes which occur in the renal pelvis and ureter are produced entirely by the secreting pressure of the kidney working against an obstructed ureteric outlet. It is owing to the oblique course of the terminal three-quarters of an inch of the ureter through the wall of the bladder that any thickening and spasmodic contraction of the vesical muscular coat interferes with the free escape of urine. Moreover, the greater the distension of the bladder with fluid under pressure, the more are the walls of the intramural portion of the ureter pressed together and its lumen occluded.

(C) **Changes in the kidney.**—Some dilatation of the renal pelvis occurs concurrently with the ureteric changes, but in cases dependent upon urethral obstruction this dilatation is rarely of such a degree as to be worthy of the title of hydro-nephrosis. The kidney becomes hollowed out and slightly enlarged, and indicates by an appearance of slight lobulation on its surface the dilatation of the calyces which is taking place in its interior. The renal parenchyma becomes thinned out and fibrotic from pressure atrophy, and may in time almost completely disappear. In the earlier stages the adherent and thickened capsule, the fibrotic renal substance containing small cortical cysts, and the fibro-lipomatous mass occupying the renal sinus are very similar to the changes seen in the ordinary form of chronic interstitial nephritis (granular kidney).

Surgical Diseases of the Kidney and Affections of the Ureter.

## Movable Kidney.

A pathologically movable kidney is one in which at least half the kidney can be felt on bimanual examination during full inspiration, and in which the stretching of its fascial supports has been such that the organ shows a diminished, or even no, tendency to return to its natural position in the loin on expiration. There are two factors acting in the fixation of the kidney under normal circumstances :—

1. The intra-abdominal pressure, which is maintained by the natural tone of the muscles of the abdominal wall.
2. The fascial supports of the kidney.

The kidney is enclosed in a fixed envelope of fascia, the peri-nephric capsule, which is deficient only in the region of the hilum. It is within this fibrous sheath that the natural respiratory or pathological movements of the kidney take place. The funnel-shaped capsule contains a mass of fat, in which the kidney is embedded. This fat is most abundant below, and forms a solid pad or cushion in the apex of the funnel, upon which the lower pole of the kidney rests. Passing from the peri-nephric capsule through the fat to the true capsule of the kidney are large numbers of delicate fibrous septa. Although, in general, much too weak to be any support to the kidney, one specialised portion of this tissue, the suspensory ligament, does act in this way. This is a definite strong fibrous band, which, arising from the true capsule of the kidney on its inner and upper aspect, passes upwards and inwards to the upper limit of the peri-nephric capsule, and from there onwards behind the suprarenal capsule to find firm attachment to the spine in the region of the crus of the diaphragm.

The tonic contraction of the abdominal muscles alone maintains the kidney in its natural position. The suspensory ligament and the peri-nephric fat are not designed to maintain a continuous influence, but only to counteract sudden jars and severe body strains.

*Pathology.*—A mobile kidney is most commonly met with in patients of between twenty-five and thirty-five years, occurs on the right side only in the proportion of almost 10 to 1, and very rarely affects men.

The great factor in its production is a relaxed condition of the abdominal wall, and in consequence a fall in the intra-abdominal pressure. This lack of muscular tone is usually an inherent congenital weakness, and is seen in individuals with long, narrow chests, much obliquity of the lower ribs, and broad, shallow loins. It may occur as the result of subinvolution of the abdominal muscles following pregnancy or the removal of large abdominal tumours, but as only a small preponderance of the cases occurs in women who have borne children, this influence cannot be regarded as an important one.

Once the muscular support of the kidney is withdrawn and a continuous strain thrown upon its fascial connections, the latter stretch and the organ becomes abnormally mobile. The kidney falls downwards and forwards into the abdominal cavity carrying the peritoneum before it, and, its lower pole being guided inwards to a certain extent by the direction of the peri-nephric funnel, the whole organ undergoes rotation through the arc of a circle having the origin of the renal artery as its centre. In extreme cases the hilum may be directed upwards with the long axis of the kidney lying almost transversely. The vessels in the renal pedicle elongate, and, with the absorption of the

peri-nephric fat, permit of free movement of the kidney within its peri-nephric sheath. As a result also of the stretching of the suspensory ligament, there is found little if any tendency of the kidney to return to its natural position in the loin on expiration. The condition of the kidney may be an isolated one, or it may form part of a general slipping downwards of the abdominal viscera. It is not infrequently found associated with cholecystitis and gall-stones and atonic dilatation of the stomach. In certain very rare instances the kidney may actually drag upon and constrict the lumen of the duodenum by means of peritoneal bands, and thus produce a true mechanical but incomplete obstruction of the bowel for a short period.

In the male a few cases are of undoubtedly traumatic origin, and are produced by some sudden violent blow in the loin which ruptures the suspensory ligament and allows the upper pole of the kidney to fall forwards. The classical example of this condition is the man who in crawling through the manhole of a boiler received a violent blow in the loin from the edge of the opening during a sudden violent roll of the ship. These cases are always severe, and are subject to acute attacks of torsion often accompanied by profuse hæmaturia.

A certain amount of twisting of the renal pedicle with kinking of the ureter may occur in any case in which it is possible for the upper pole of the kidney to fall forwards and, for the time being, to be fixed in this position by coils of gut slipping behind it. The venous return being interfered with, the kidney enlarges and becomes deep purple in colour. The ureter also suffers, and if these attacks of obstruction are often repeated, an intermittent hydro-nephrosis will result. As a matter of experience, it is found that a hydro-nephrosis is an uncommon complication of movable kidney, and, when it occurs, will often be found in association with an aberrant renal artery, a narrowing of the ureteric strait, or some other congenital anomaly.

The polyuria which occurs after one of these acute attacks of kinking may be the emptying of a hydro-nephrosis, but is usually due to the property the kidney possesses of secreting a large amount of dilute urine of low specific gravity, when the renal stasis is relieved.

As seen at operation during a quiescent period, a movable kidney is a pale, flabby organ with here and there on its capsule white triangular patches at the site of attachment of the peri-nephric fibrillæ referred to above. This is a purely surface change, and the capsule strips readily. Slight dilatation of the extra-renal portion of the pelvis may be seen, but there is no evidence that mobility either predisposes towards the formation of stone or hastens the onset of a chronic interstitial nephritis.

*Symptoms and signs.*—There is no relation between the degree of mobility of the kidney and the symptoms produced by it. A kidney which has dragged out a peritoneal pedicle for itself may be so freely movable that it lies immediately beneath the anterior abdominal wall (*floating kidney*), and yet the patient may not suffer the slightest inconvenience or know of its presence. The cases in which symptoms are present may be divided into :—

1. Those subject to acute paroxysmal attacks of pain.
2. Chronic cases.

1. *The acute cases.*—Comparatively well between the attacks, these patients may at any moment be subject to paroxysms (*Dietl's crises*), brought on perhaps by some unusual exertion. The attack is ushered in by severe diffuse abdominal and lumbar pain, accompanied by vomiting and a considerable rise in the pulse rate. There is often a slight amount of fever, and in some few instances the vomiting may be the predominant feature. In the early

stages, before tympanites masks the physical signs, the kidney can be felt to be enlarged and tender, and very little urine is passed. Within a few hours, rarely more than twelve, the pain gradually ceases, and the patient passes a large amount of urine of low specific gravity containing a trace of albumen. Hæmaturia and an intense desire to micturate during the attack may be present, but these are unusual. In the acute stage the diagnosis is not easy, and the passage of a ureteral stone, appendicitis, acute cholecystitis, and perforation of the bowel have to be excluded.

2. *Chronic cases.*—Here pain is the one prominent feature, fixed aching lumbar pain, more diffuse than that of stone, passing round the loin to terminate in a dragging sensation in the corresponding iliac fossa. The pain comes on when the patient is tired, may be relieved by recumbency, and is worse at the time of the menstrual periods. There is sometimes a feeling of something moving about in the abdomen, and the patient may actually feel the offending kidney, which she describes as a painful lump. Many of the patients are hopeless neurasthenics. In some the pain attributed to the kidney condition may be regarded as merely an incident in a primary neurasthenia; in others the continuous aching pain produced by the renal drag is the initial condition and so acts on an already weak and imperfectly developed nervous system that in time the patient is reduced to a condition of absolute nervous prostration.

*Treatment.*—Many cases of movable kidney present no symptoms directly attributable to this condition, and it is the greatest possible mistake on the part of the surgeon either to attempt to treat the condition or to inform the patient herself of it. An operation of fixation (*nephrorrhaphy*) should be carried out in the quiescent period in all cases subject to acute attacks, because here an absolute cure of the crises can be promised and an initial condition of hydro-nephrosis, if it exists, be prevented from going further. The aching pain of the quiescent interval also will be greatly relieved if not actually prevented. If seen during one of these acute attacks the patient should be placed in the prone position with the foot of the bed and pelvis raised a few inches. The pain should be relieved by hot fomentations and morphia, and often gentle manipulation of the loin will suddenly result in the dislocated kidney slipping back into its proper position.

Operation in the chronic cases, on the other hand, should not be lightly undertaken until other less radical means have been given a fair trial. No patient in whom recumbency does not relieve the lumbar pains should be operated upon. General visceroptosis is an absolute contra-indication, and those patients in whom a condition of neurasthenia co-exists are particularly unfavourable, unless it is certain that the renal condition is the primary one.

Palliative treatment consists in providing the patient with some form of mechanical support, and of the many in use a broad elastic abdominal belt, applied during recumbency, is the best to employ. If at the same time the patient's general resistance is built up by rest, a generous diet, and massage, the pain except for occasional exacerbations will become a negligible feature. In these cases nephrorrhaphy as a rule will give no better results, but if apparently severe pain still continues in spite of treatment, the matter should be placed fully before the patient's friends and operation given a fair trial.

The exact details of lumbar fixation matter little, provided the posterior aspect of the kidney, bared by reflection of its capsule, is placed in direct contact with the lumbar muscles. No method of suturing, however elaborate, will permanently fix the kidney, unless firm fibrous adhesion of the cortex of

the gland is obtained. The decapsulation methods will secure this, and will not damage the renal parenchyma. No attempt should be made to replace the kidney into what is regarded as its correct anatomical situation, unless there is room for it in this position. Every case should be treated on its merits, and the kidney so fixed that the liver does not press downwards upon

FIG. 417.—Bilateral hydro-nephrosis. The urogenital organs of an infant, aged five months, who suffered from an attack of acute retention of urine due to phimosis. (St. Bartholomew's Hospital Museum.)

it. There must be no tension upon its vascular pedicle. The patient should be nursed in the prone position and confined to bed for at least three weeks after operation.

## Hydro-nephrosis.

*Pathology.*—A hydro-nephrosis is a kidney in which, as the result of some mechanical obstruction in the distal portion of the urinary tract, dilatation of

its pelvis and calyces has occurred, accompanied by absorption ot some of the renal parenchyma and an interstitial fibrous change in the remainder.

The kidney is usually lobulated and, in its earlier stages, takes the contour of the dilated calyces. It may be only slightly enlarged, or may form a large thin-walled fibrous sac, containing fluid resembling very dilute urine of specific gravity 1,005—1,008 and occupying a large portion of the abdominal cavity.

**Bilateral hydro-nephrosis.**—If the obstruction is in the lower urinary tract

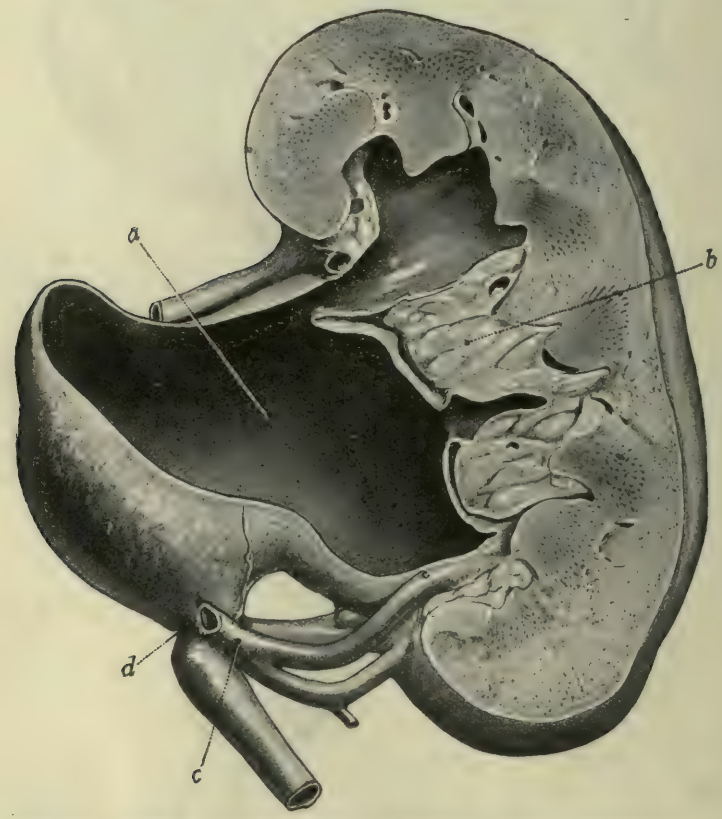



FIG. 418.—Hydro-nephrosis secondary to stenosis of ureter produced by an aberrant renal artery. *a*, Dilated pelvis of kidney. *b*, Fat in renal sinus. *c*, Aberrant renal artery. *d*, Stricture of ureter. (St. Bartholomew's Hospital Museum.)

both kidneys are involved equally, but the tumours are not usually large enough to be appreciated clinically.

Examples of this form of obstruction are :—

1. *Congenital.*—A tight phimosis, an imperforate urethra, or a pinhole meatus, the latter being often associated with a small fistula on the under surface of the glans penis immediately behind the frænum. One of these causes, acting over a period of many years, may occasionally produce a swelling large enough to be detected during life.

2. *Acquired.*—Urethral stricture and enlargement of the prostate. In these cases the kidneys show very little enlargement and *post mortem* are practi-

cally always found to be infected ; the dilated pelvis contains purulent urine, and minute suppurating foci are found in the parenchyma (*consecutive pyelo-nephritis*).

If for any other reason also the bladder is irritable and has thick hypertrophied muscular walls, the obstruction to the ureter in the intramural por-

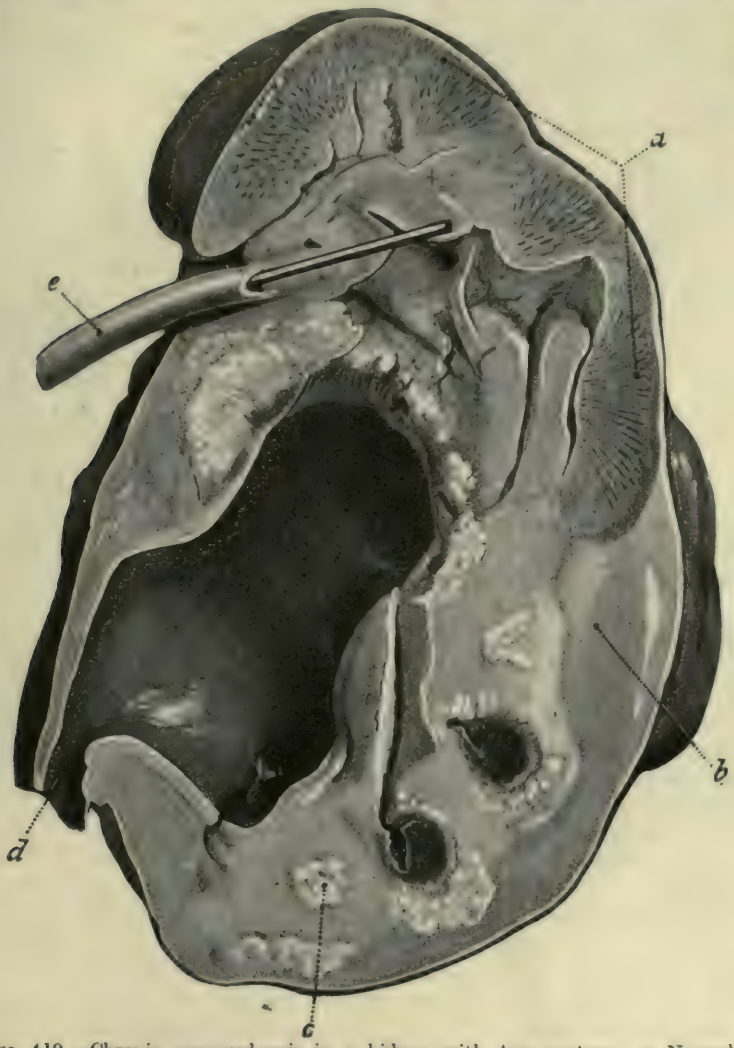



FIG. 419.—Chronic pyo-nephrosis in a kidney with two ureters. *a*, Normal renal tissue. *b*, Dense fibrous tissue. *c*, Patch of necrotic kidney substance. *d*, Thickened and dilated ureter draining a much-enlarged pelvis. *e*, Normal ureter. (St. Bartholomew's Hospital Museum.)

tion of its course may be responsible for dilatation of the renal pelvis ; it is probable that the bilateral hydro-nephroses found in patients suffering from ectopia vesicæ are produced in this way.

**Unilateral hydro-nephrosis** is produced by any form of obstruction in the renal pelvis or ureter.

If the obstruction is sudden, complete, and permanent, as in ligature of a

ureter divided accidentally in the course of a pelvic operation, a small, temporary, and painless hydro-nephrosis of the corresponding kidney results. In a few months this disappears and the kidney atrophies.

If the obstruction is sudden and practically complete, but at the same time intermittent, as in that occurring in some cases of stone, movable kidney, or villous growth of the renal pelvis, a fair-sized tumour is produced, which, when the obstruction is relieved, will disappear clinically for the time being. It may again be emphasised that hydro-nephrosis is an uncommon complication of movable kidney, and that a small percentage only are produced in this way.

If the obstruction is incomplete but permanent, a large hydro-nephrosis is produced. In the congenital cases where the common lesion is a stricture of the ureter, the swelling may be enormous and consists chiefly of a greatly-dilated pelvis, the body of the kidney suffering to a less degree. The stricture is usually situated at the upper end of the ureter (*ureteral strait*), and it is not uncommon to find an aberrant artery to the lower pole of the kidney crossing in front of or behind the ureter at the site of stenosis. It is a curious fact that clinically these cases of aberrant artery are subject to acute attacks of pain and distension of the pelvis, and yet often no abnormal mobility of the kidney or other cause of sudden kinking of the ureter can be discovered.

At the time of operation the ureter may be found opening very obliquely into the renal pelvis ; this is not to be regarded as the primary cause of the hydro-nephrosis, but rather as a secondary result of the dilatation of the pelvis. If the stricture is at the ureteral orifice into the bladder, it may be associated with a double ureter, and in that case only part of the kidney may be affected.

Examples of acquired causes are :—Tumours of the pelvic viscera or bones, stenosis of the ureter following an injury or an impacted stone, and occasionally the pressure of the pregnant uterus on the right ureter at the brim of the pelvis.

As carcinoma of the cervix spreads outwards into the parametrium it usually involves one ureter more than the other and a hydro-nephrosis is produced, but this is soon converted into a pyo-nephrosis. In cases of uretero-vaginal fistulæ due to post-operative sloughing of the ureter after a complete hysterectomy for carcinoma, there is usually a certain amount of ureteral obstruction caused by the dense cicatricial tissue which forms round the fistula. This is also followed by a hydro-nephrosis.

*Symptoms and signs.*—There are two clinical types of hydro-nephrosis.

1. **The constant form.**—Here there is a globular elastic swelling in the loin with a smooth or slightly-lobulated surface. It is movable, painless, not tender on palpation, and possesses all the usual characteristics of a renal tumour. Subjective symptoms are usually absent, but in the later stages of the bilateral cases there will be the headache, thirst, lassitude, and vomiting of chronic uræmia, which in the end carries the patient off. Copious amounts of a pale dilute urine often containing a trace of albumen are passed.

2. **The intermittent form.**—An attack of ureteral colic precedes the appearance of a tender, elastic swelling in the loin. The tumour is usually very tense, and preserves to a great extent the natural shape of the kidney. The cessation of pain is followed by the passage of a large amount of dilute urine and the disappearance of the tumour. If the attacks are severe they may be accompanied by hæmaturia.

*Treatment.*—The condition of the opposite kidney having been investigated and found to be satisfactory, the hydro-nephrosis should be exposed from the

loin and dealt with, because, apart from any discomfort its presence may cause the patient, it is always liable to the risk of infection.

If the kidney is found to be represented by a large, thin-walled sac, it should be reduced in size by puncturing with a trocar and cannula so that it can be delivered through the ilio-costal space and then removed. The vessels in the pedicle will be small and will give no trouble. If the tumour is of moderate size only and still contains a fair amount of active secreting tissue in its walls, every effort should be made to discover the cause of the obstruction and to relieve it. A large incision should be made in order to get a good preliminary view of the kidney and upper portion of the ureter *in situ*, because if once brought out on to the loin any kinking or obliquity of the ureter will be obliterated.

An offending stone should be removed, a movable kidney fixed in a suitable situation, or an aberrant renal artery obstructing the ureter divided, bearing in mind that the latter is often actually stenosed at the spot where it is crossed by the artery.

A stricture at the commencement of the ureter can be treated by one of two methods. The pelvis can be opened and the stricture dilated by the passage of ureteric bougies, or a lateral anastomosis between the dilated pelvis and the ureter on the distal side of the stricture carried out. If these operations fail to relieve the obstruction permanently, nephrectomy will have to be performed at a later date.

## Pyo-nephrosis.

A pyo-nephrosis is a lobulated swelling of globular or reniform shape, and is derived from a kidney the secreting substance of which has been partially or wholly destroyed by combined processes of back-pressure and suppuration. The kidney may show little or no enlargement, but in extreme cases forms a tumour occupying the greater part of the abdominal cavity.

*Pathology.*—A pyo-nephrosis is an enlarged skeleton of a former kidney. It consists of a number of imperfectly separated compartments, filled with pus, and contained by the dilated walls of the original renal pelvis and calyces. The walls of these compartments are composed of the tissues of the renal parenchyma in varying stages of degeneration. The tumour is surrounded by an adherent fibro-lipomatous sheath derived from the fatty capsule of the kidney and may contain numerous secondary phosphatic calculi.

*Varieties.*—(*a*) Cases of hydro-nephrosis which have become secondarily infected, the commoner organisms found being *bacillus coli*, staphylococci and *B. proteus*.

Where the original cause of the hydro-nephrosis has been a lesion high up in the course of the ureter, the greater part of the tumour is formed by the much-ballooned and thickened pelvis, whilst the sclerosed kidney, dilated to perhaps twice its natural size, is super-imposed upon one aspect of the swelling. The organisms reach the kidney, either by the blood-stream or by direct invasion from the bowel.

If the renal dilatation is secondary to some obstruction in the lower urinary tract, such as enlargement of the prostate or urethral stricture, the infection comes from below. Under ordinary circumstances an intact ureteric opening is an effective barrier to an ascending infection, but once its valvular arrangement is interfered with and the dilated ureter is in free and open communication with the bladder, organisms can readily pass upwards in the resulting stagnant column of urine and thus reach the pelvis of the kidney. There is

a certain amount of experimental evidence to show that the lymphatics of the ureter also form a possible channel for an ascending infection.

(*b*) Infection of apparently healthy kidneys (acute primary suppurative pyelo-nephritis). The great majority of these cases are unilateral, occur in women and children, and are due to some bacillus of the coliform group. The renal pelvis is little, if at all, dilated, and the tumour is entirely composed of the enlarged and dilated kidney (see p. 1124).

(*c*) Tuberculous disease of the kidney (see p. 1129).

*Symptoms and signs.*—The cardinal symptoms of pyo-nephrosis are the presence of a tumour in the loin, fever, pain, and pyuria.

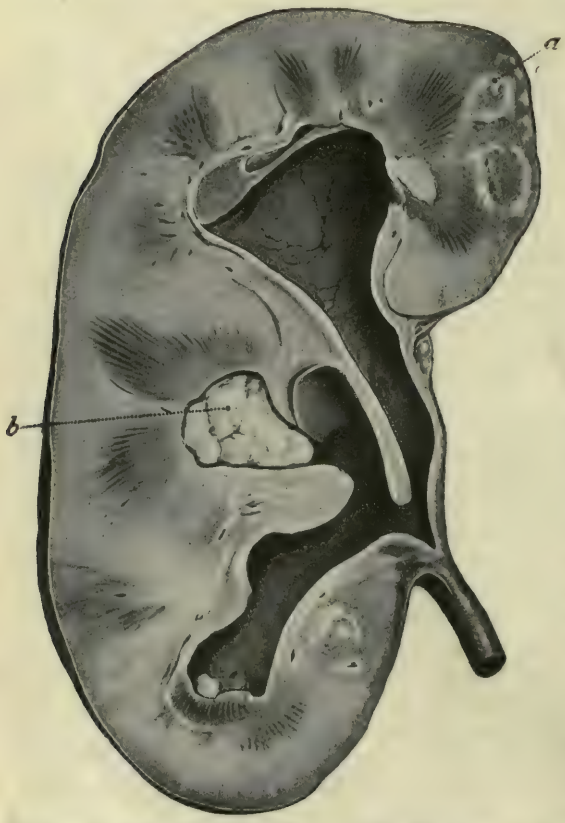



FIG. 420.—Ascending suppurative pyelo-nephritis. The lesion was the result of a *B. coli* infection following complete hysterectomy for carcinoma of the cervix. *a*, Patch of bacterial necrosis in cortex. *b*, Inspissated pus in dilated calyx. (St. Bartholomew's Hospital Museum.)

1. *Tumour.* — The tumour has many of the characters of a hydro-nephrosis. In addition there is some tenderness and muscular rigidity in the loin of the affected side. The mobility of the swelling varies. In the acute primary pyelo-nephritis cases the enlarged kidney moves on respiration, and a certain amount of lateral mobility can be conveyed to it by the examining finger; on the other hand, a calculous pyo-nephrosis of some years' standing is absolutely fixed.

2. *Fever.* — These cases show an almost constant slight rise in temperature to 99·5° or 100° at nights. At intervals of a few days or weeks, however, when blocking of some portion of the ureter coincides with a clearing of the urine, the temperature may rise to 102° or even higher. A widely ranging intermittent chart of 103° to 105° often denotes peri-nephric suppuration. As a result of septic absorption the patient is usually pale and thin.

3. *Pain.*—An almost constant lumbar ache, worse at nights, is sometimes associated with mild attacks of ureteral colic.

4. *Pyuria.*—The urine usually contains much pus which settles down in a heavy mass in the bottom of the specimen glass, the liquid above having a

hazy, milky appearance. A temporary clearing of the urine is often associated with an increase in the size and tenderness of the tumour.

The diagnosis is made on the history of the condition of the urine, the character of the abdominal swelling and the fever associated with pus in the urine. Cystoscopic examination will often reveal semi-solid columns of pus being slowly extruded from the ureteric opening of the affected side.

*Treatment.*—The best treatment for pyo-nephrosis is a primary nephrectomy by the lumbar route, the tumour, together with the diseased portion of the ureter, being removed from within its capsule of thickened and adherent peri-nephric fat. If the patient is desperately ill a drainage operation, which is invariably followed by a persistent sinus, may be all that is possible at the time. Secondary nephrectomy will have to be considered at a later date. It is a very difficult and dangerous operation at this stage, when profuse peri-nephric suppuration has been in operation for a period of weeks or months.

## Peri-nephritis.

By peri-nephritis is meant inflammation in the region of the kidney, the lesion being within or without the peri-nephric sheath. It may be acute or chronic.

(*a*) **Acute peri-nephritis. Peri-nephric abscess.** — *Pathology.* — Peri-nephritis is usually a disease of adults and occurs more frequently on the right side. It may arise spontaneously, following some acute septic condition such as tonsillitis, or may occur during the course of one of the acute specific fevers. Usually it is secondary to some injury or disease of the kidney or neighbouring organs. A severe laceration of the kidney is followed by the formation of a hæmotoma, often of considerable size, in the loin ; this may suppurate, and is especially liable to do so if the injury to the pelvis or ureter has allowed the escape of urine

Any inflammatory disease of the kidney may be followed by the formation of pus within the peri-nephric sheath, common examples being calculous disease, pyo-nephrosis and pyelo-nephritis.

The commoner diseases of neighbouring organs giving rise to suppuration around the kidney, usually outside the peri-nephric sheath, are appendicitis, tuberculous disease of the spine or ribs, perforated or leaking duodenal ulcer (on the right side), and empyema.

Three main varieties are described :—

1. *Superior or sub-phrenic.*—Here the abscess is situated high up immediately under the diaphragm and tends to push the kidney downwards as it increases in size.

2. *Posterior.*—In this, the commonest, variety the pus lies behind the kidney and usually finds its way to the surface either at the outer border of the erector spinæ or through the intermuscular interval above the iliac crest (Petit's triangle).

3. *Inferior.*—Usually arising from suppuration in a retro-colic appendix, the pus gradually extends downwards into the iliac fossa ; it occasionally perforates the fascial sheath of the psoas muscle and, penetrating beneath Poupart's ligament, may actually point in the thigh.

*Symptoms and signs.*—The symptoms of this condition may be, to a great extent, masked by those of the primary disease. Thus, after the initial symptoms of acute appendicitis or leaking duodenal ulcer have partially subsided, a gradually increasing swelling in the loin may be detected, accompanied by increased fever, sweating, wasting, and other signs of septic absorp-

tion. The swelling tends to bulge backwards into the loin and to show less definition of outline, and more tenderness, overlying muscular rigidity, and fixity than a pyo-nephrosis. Some œdema of the superficial tissues of the loin is usually present, and there may be actual reddening of the skin in this situation. If the abscess is secondary to a renal lesion pus will be found in the urine and it may be possible to elicit the history of a preceding renal calculus or pyo-nephrosis. When, on the other hand, the suppuration has followed tuberculous caries of the spine or a rib, a considerable bulging of the flank of the affected side may alone have drawn the patient's attention to the condition ; it is accompanied by little or no fever, pain or local tenderness.

*Treatment.*—A peri-nephric abscess should be explored from the loin and drained by an incision somewhat similar to that employed for exposing the kidney by the lumbar route. If the latter is the primary source of the suppuration it should be freely incised along its convex border at the same time and drained also. Nephrectomy, if necessary, is better left until a later date.

(*b*) **Chronic peri-nephritis.**—In this condition, which is practically always secondary to renal disease, the fatty capsule of the kidney, lying within the peri-nephric sheath, is converted into a dense fibrous or fibro-lipomatous mass. The fibrous type is seen in long-standing cases of calculous disease and forms a thick dense sheath, firmly adherent to the true capsule of the kidney, and constricting and crushing the latter. The kidney gradually contracts adhesions to the colon, the duodenum, peritoneum and diaphragm, and nephrectomy becomes an exceedingly difficult and dangerous operation. In these circumstances, however, it is usually possible to remove the kidney by enucleating it from within its own true capsule (sub-capsular nephrectomy). The fibro-lipomatous form, in which the soft, granular peri-nephric fat is converted into a tough lobulated mass, is met with in cases of chronic pyelo-nephritis or chronic interstitial nephritis, and, in the latter, a well-marked mass of fatty tissue almost completely blocks up the renal sinus.

The symptoms, prognosis and treatment of this condition are those of the primary renal disease giving rise to it.

## Congenital Cystic Disease.

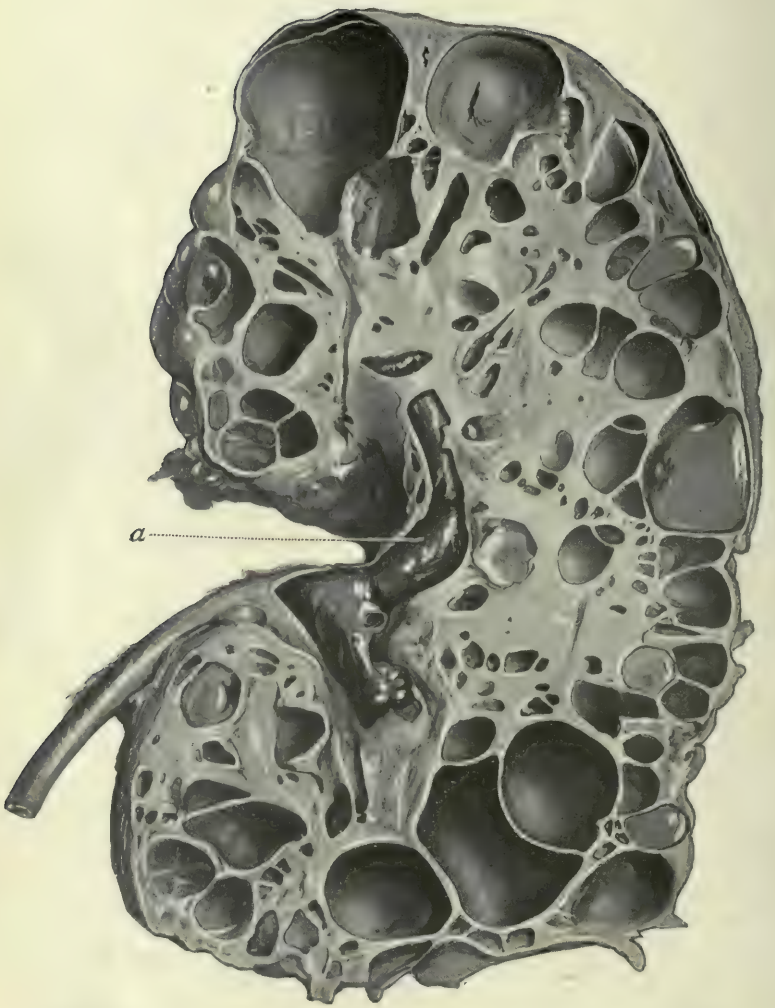
*Pathology.*—Congenital cystic disease of the kidney may show itself at any age, but is usually met with clinically either during infancy or in patients between the ages of twenty and forty years. It is commoner in females. Although one kidney may exhibit the disease in a much more advanced form and be the only one palpable, yet *post mortem* the opposite kidney will be found to be affected to a lesser degree, and, with the rarest of exceptions, the condition must be regarded as a bilateral one. It may be associated with other congenital abnormalities of the urinary tract, such as a pin-hole meatus or a tight phimosis, and a hydro-nephrosis may be present in one or both kidneys in addition. Congenitally misshapen organs, such as the horse-shoe kidney, or congenitally misplaced kidneys, are more liable to be affected than those in which development has progressed along normal lines.

There are three main theories of origin :—

1. That the primitive metanephric duct, finally represented by the ureter, pelvis and collecting ducts, has failed to unite with some of the secreting tubules of the kidney, and that as the result of this large numbers of retention cysts have occurred in the latter.

When the disease is only discovered in adult life it may be assumed that

Plate 30.




Polycystic disease of the kidney. A large blood-clot is seen at (*a*) occupying the renal pelvis and calyces. (St. Bartholomew's Hospital Museum.)

either the condition has progressed very slowly, or that it has only begun to develop after adult life has been reached, as is seen in cystic conditions arising in the par- or ep-oöphoron, or other fœtal remnants.

2. That the tumour is a cystic adenoma of the normal renal tubules.

3. That interstitial fibrosis of the kidney is the primary condition, and that the cystic spaces are distended renal tubules, comparable in their mode of origin to the small cortical cysts of ordinary granular kidney.

The enlarged kidney preserves its natural shape, and, although the whole organ is usually involved equally, one portion only may show the cystic change. The latter condition is almost always confined to congenitally misshapen kidneys.

The cysts vary in size from a pin's head to a billiard ball, and are scattered universally throughout the kidney, the surface being studded with them. They range from a light yellow to a dark brown colour, are semi-translucent, and contain clear liquid or thick grumous fluid stained by extravasated blood. The individual cysts are separated by a varying amount of kidney substance showing little or much interstitial fibrosis, but in a more advanced case the tumour may consist of a conglomeration of cysts welded together by a minimum amount of fibrous tissue only.

*Symptoms and signs.*—The one constant sign of cystic disease of the kidney is a painless swelling with the usual characteristics of a renal tumour in one or both loins. The kidney retains its natural shape, the enlarged organ has a more extensive respiratory excursion and is more movable than the normal kidney. It feels hard and solid, and the surface may be nodular. The tumour may be present at birth and may be so large as to obstruct delivery. Bursts of hæmaturia often occur from time to time associated with mild attacks of ureteral colic, and the pain may precede the appearance of blood in the urine by as much as one or two hours. There may also be a certain amount of aching pain in the front of the loin, passing downwards into the iliac fossa, and occurring independently of hæmaturia. This pain is usually worse towards the end of the day and is relieved by recumbency. The urine varies in amount from day to day, sometimes being in excess of the normal, at other times diminished in quantity. It is pale, of low specific gravity, 1,005—1,013, and may, apart from the presence of blood, contain a haze of albumen, although this is by no means a constant feature.

The impairment of the renal function is well shown by the intramuscular injection of a solution of indigo-carmine. The time of appearance of pigment in the urine may be delayed by as much as one hour in these cases.

Infants suffering from cystic kidneys rarely live more than two or three years, and its bilateral character will help to distinguish the disease from sarcoma of the kidney, which in many ways it resembles. When the disease does not show itself until adult life it appears to progress more slowly, and these patients may live to the age of fifty years or more. The associated condition of chronic interstitial nephritis is a slowly progressive one, and the patient passes eventually into a state of chronic uræmia with well-marked cardio-vascular changes.

*Treatment.*—No treatment other than that employed in cases of granular kidney is possible. Seeing that the condition is a bilateral one, nephrectomy cannot be considered. Indeed, if polycystic kidneys are suspected, every possible means should be employed to establish the diagnosis without exploration, because any form of surgical interference may be just sufficient to throw the already embarrassed kidneys off their balance and provoke a fatal issue from uræmia within three or four days of operation.

## Stone.

*Pathology.*—Bladder stone has a very definite geographical distribution. It is common in certain English counties such as Norfolk, in Egypt, and in the dry and wheat-eating districts of Central India. Renal stone, on the other hand, seems to be more evenly distributed both at home and abroad. In India it is uncommon as compared with bladder stone, and of no more frequent occurrence than in this country.

The cause of stone is unknown, but one factor of importance is undoubtedly bacterial action. Infection of the bladder with staphylococci, commonly seen in the stagnant urine of prostatic and stricture cases, certainly leads to the splitting up of urea into simpler ammonium salts and the deposition in the alkaline urine so produced of triple phosphate in the form of calculi. The plug of mucus or blood-clot which often forms the centre of oxalate stones can also be shown to contain organisms in many instances. At the same time it is difficult to understand why, whereas *bacillus coli* infections of the urinary tract are infinitely more frequent in female children and women, yet renal stone is slightly more common in men. The comparative immunity of women from stone in the bladder can be readily explained by the anatomical arrangement of their lower urinary tract, and the ease with which small stones are got rid of *per vias naturales*. It is a noticeable fact that many patients who owing to a faulty metabolism pass large quantities of crystals (*oxaluria* or *phosphaturia*) or gravel in their urine, never develop stones. It may be that both these factors are essential, and that bacterial fermentation gives rise to some mucoid material, which causes the abnormal amount of crystals present to adhere together and form a stone.

Bladder stone in Norfolk to-day is infinitely more rare than it was during the past decade, and the great improvement in the hygienic arrangements and diet of the present generation has been invoked as an explanation of this. Moreover, uratic stones are undoubtedly more common in the children of the poor, where presumably improper feeding is more likely to occur, yet in India they are not unknown in infants who have been entirely breast-fed.

**Varieties of stone.**—1. *Calcium oxalate calculi.*—These, the commonest of all stones, are most frequently met with in young adults. They are extremely hard, and vary from a shining white to black, being usually stained a brownish-black colour by altered blood pigment. They occur in acid urine, show well under X-rays, and on section have a concentric laminated structure. In the centre of the stone these laminæ form a series of regular lines of varying shades of colour, but as the periphery is approached they usually take on a more wavy and undulating appearance corresponding with the irregularities often seen on the surface of these stones. There are two main types :—

(*a*) Small flattened stones, about the size of a finger-nail, with smooth, polished surfaces. They are often multiple and occur in dilated calyces. An oxalate stone in the renal pelvis becomes moulded into a flattened cone, with two or three knob-like processes projecting from its base into, and blocking, the mouths of the calyces.

(*b*) Solitary globular stones, with rough tuberculated (*mulberry calculus*) or even spiculated surfaces. They take many years to form, are exceedingly dense, and are usually found in the bladder.

2. *Phosphatic calculi.*—These commonly consist of the triple phosphate (*ammonium magnesium phosphate*) with nuclei of calcium oxalate, their appearance suggesting the embedding of the latter in a plaster cast. They are composed of a dirty white, friable, amorphous material, which, although

BLADDER CALCULI. (Westminster Hospital Museum.)

1. Calculus in section. The nucleus is composed of urate of ammonium, outside which are alternate layers of urates and oxalate of lime, covered by phosphate of lime.
2 and 3. Cystin calculi.
4 and 5. A calculus. 4, in section; 5, the surface. The surface presents dark mammillated processes of oxalate of lime, between which the stone is covered by laminæ of urates. In section the large central nucleus is seen to consist of oxalate of lime. It is surrounded by alternating laminæ of phosphates, urates and oxalate of lime, the outer layers of oxalates being mixed with blood.
6. A calculus, the nucleus of which is composed of urate of ammonium; around this are deeper coloured layers of oxalate of lime; the outside crust consists of phosphates.
7 and 8. Oxalate calculi.

it does not appear to have any definite structure, yet cracks off its nucleus in shell-like pieces. They occur in alkaline stinking urine, and are preceded by some bacterial infection, commonly staphylococcal, of the urinary tract. Their surface is slightly roughened, and they show a fair shadow under X-rays, if they are not embedded in the pus and thickened tissue of a pyo-nephrotic sac. Almost pure calcium phosphate stones are met with very occasionally in neutral or faintly acid urines, and have much the same physical characters.

FIG. 421.—Hydro-nephrosis. The hydro-nephrosis is due to a stone impacted at the ureteral strait and has become secondarily infected. *a*, Areas of bacterial necrosis in renal cortex. *b*, Impacted stone. (St. Bartholomew's Hospital Museum.)

3. *Uratic calculi.*—Stones composed of sodium and ammonium urate, containing traces only of uric acid, are not infrequently met with in children. They are yellowish-brown in colour, have a smooth, sometimes polished, surface, and on section are brittle and show a very definite laminated structure. They occur in acid urine, are usually multiple, and do not attain any great size. Oxalate stones have often been mistaken for them in the past, and they are not nearly so common as was formerly supposed. Pure uric acid stones

are rare, if the small rounded pea-like bodies passed by elderly men, and usually referred to as gravel, are excluded.

Uratic calculi cast a faint, ill-defined shadow under X-rays, and even this is entirely due to the oxalic and phosphatic impurities they contain.

4. *Cystin calculi.*—Cystin is one of the less complex substances into which the protoplasm of the body is split up during katabolism. It contains most

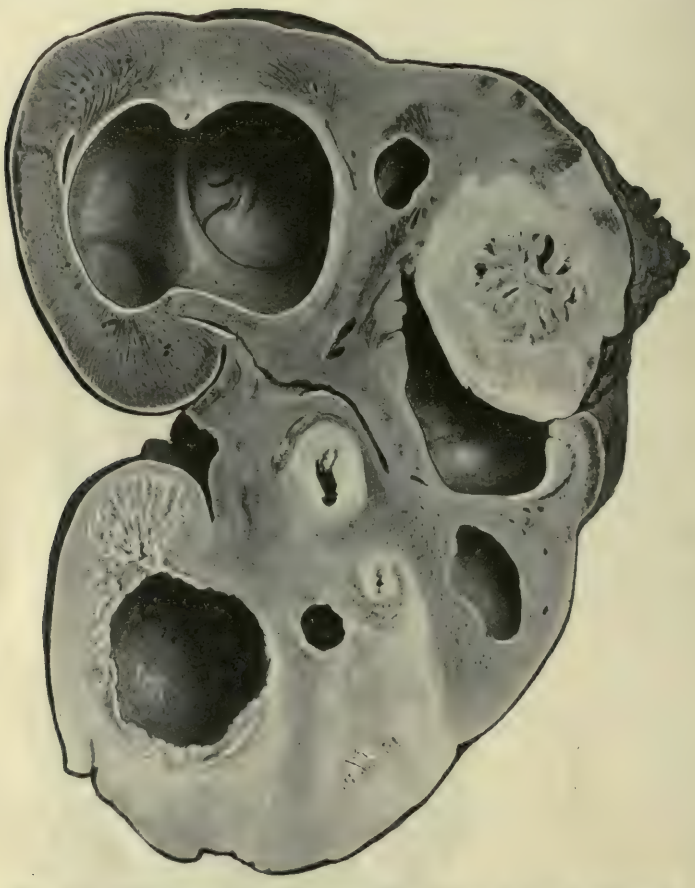


FIG. 422.—Calculous pyo-nephrosis. The kidney is much enlarged, partly by distension of the calyces, partly by fibro-caseous deposits. The large reticulated fibro-caseous mass forms a projection on the convex border of the kidney. In its lower half the renal substance appears to be entirely replaced by pale fibrous tissue. (St. Bartholomew's Hospital Museum.)

of the sulphur of the original protein molecule, and, owing to some hereditary defect in the oxidation of the tissues, it is excreted as such in the urine instead of as the simpler sulphate of normal individuals.

Cystin stones are very rare, and when first passed have a semi-translucent, yellow appearance. As seen in museums, they are large spherical green stones with a slightly roughened, uneven surface. On section they exhibit a well-marked radiating and concentric striation, and cast a darker and better defined shadow under X-rays than any other variety of calculus.

**Renal changes as the result of stone.**—Once a stone has been formed in the kidney a series of mechanical and, later, infective processes takes place which, if the calculus is not passed or removed, will slowly but surely destroy the organ. A stone impacted in one of the calyces will act as a foreign body and irritant. It produces a surrounding local fibrosis, which if allowed to progress may in time spread to a condition of generalised chronic interstitial nephritis. The affected calyx, the mouth of which is often blocked, will gradually dilate and produce a certain amount of enlargement and lobulation of the kidney, as its secreting substance is either gradually removed or converted into a thin layer of fibrous tissue. As additional calyces are involved, the changes become more general, and in time the kidney may completely atrophy into a fibrous sac full of stones. If the stone lies in the pelvis or is impacted in some portion of the ureter, and from time to time causes a complete blockage by acting as a cup-and-ball valve, the pelvis and calyces will rapidly dilate, and, absorption of the renal substance going on hand in hand with this, a large hydro-nephrosis will be produced. Given an impacted renal stone, direct infection by organisms from the colon is usually only a question of time, and the microscopic quantities of pus found in the urine of patients suffering from renal calculus are a sure indication of a gradually progressing, quiet pyelitis. An acute attack of pyelo-nephritis may supervene at any time, and minute foci of suppuration occur in the renal parenchyma (*surgical kidney*) and lead to suppression of urine.

A pyo-nephrosis may appear within a week or two of one of these acute attacks of pyelo-nephritis, but, on the other hand, may take many months to develop before it is large enough to be appreciated as a tumour within the abdomen. Leakage from the pyo-nephrotic sac may occur and produce a large lumbar abscess, which if left to itself may point in the loin and lead to widespread suppuration and a persistent sinus, through which urine, pus, and small stones continue to drain away. This condition, if untreated, will persist until infection of the opposite kidney supervenes, and the patient gradually wastes and dies from suppression of urine or amyloid disease.

*Symptoms and signs.*—Pain and hæmaturia are the two great symptoms of renal stone, and of these the former is much the more important and often occurs alone, especially in children. *Painless hæmaturia is not a symptom of calculus.* A stone firmly embedded in a dilated calyx may not give rise to any symptoms, but this must be regarded as exceptional, as usually, at some period of its existence, a certain amount of lumbar ache will have been experienced. In an aseptic case the symptoms are only present in the daytime when the patient is moving about, and their onset is often determined by some sudden body movement or vigorous form of exercise.

The pain experienced may be of two kinds :—

(*a*) *Post-renal pain.*—This is a severe ache high up in the lumbar region with its point of maximum intensity localised in the posterior renal angle. The patient gives a very characteristic demonstration of this by tucking the thumb into the small fossa below the last rib. From this point the pain passes forwards, and is often indicated by the sufferer grasping his own loin. This pain is strictly unilateral, lasts for a few days at a time, and may then intermit completely for a period of days or even weeks.

(*b*) *Anterior renal colic.*—From time to time the patient may experience violent paroxysms of abdominal pain, which are caused by a movable stone in the renal pelvis and are brought on by some unusual form of exercise. The pain, which comes on suddenly, is referred to the anterior abdominal wall some little distance below the tip of the ninth rib. It radiates downwards

along the linea semilunaris and is referred to the distribution of the genito-crural nerve on the front of the thigh, and in the testicle. The latter is drawn up to the external ring by spasm of the cremaster muscle, is exquisitely tender,

Fig. 423.—An X-ray photograph of a stone in the lower pole of the kidney.

and may remain so for weeks after the attack. The pain is much more violent than that caused by any other renal condition, and the patient, entirely losing control of himself, may roll about on the floor in the greatest agony. He is pale, sweats profusely, vomits, and shows all the signs of severe shock with a rigid retracted abdomen. The paroxysms, lasting five or ten minutes at

a time, are interspersed with periods of severe lumbar aching, and this condition of affairs may continue for several hours before comparative relief

FIG. 424.—A calcareous tuberculous abdominal lymphatic gland simulating renal stone. The varying density, giving the shadow a mottled appearance, and indefinite margin are well shown. (From a skiagram taken by Dr. Finzi.)

is obtained. During the attack small quantities of urine are passed by frequent and painful actions of the bladder, but as the abdominal pain passes

off it is often followed by the secretion of a large amount of dilute urine of low specific gravity.

The hæmaturia is seldom profuse, amounting to little more than a general smoky staining of the urine, and comes on an hour or so after the onset of the pain. The urine usually clears during the subsequent twenty-four hours, and the patient may not have such another attack for several months ; indeed, it is characteristic of renal stone that the patient should enjoy long periods of immunity in which the discomfort experienced is comparatively slight.

The *diagnosis* of renal stone is suggested by a consideration of the symptoms, and is confirmed by X-ray examination. The physical signs of an uncomplicated aseptic case are few. The kidney is seldom palpable, and little will be found beyond slight tenderness in the post-renal angle and front of the loin, and a certain amount of rigidity of the overlying rectus muscle. Later, with an infected kidney, there will be marked tenderness of the organ, and, exceptionally, the presence of a pyo- or hydro-nephrosis may be detected. The characters of the urine depend upon whether an infected or an aseptic case is under consideration. It is usual after an attack of severe post-renal aching to find, microscopically, a certain number of pus cells and even red corpuscles, although nothing may be detected with the naked eye. In cases of calculous pyo-nephrosis intermittent obstruction is the rule, and profuse discharges of pus down the ureter occur, lasting for periods of three or four days at a time. Clearing of the urine will be followed by increased tenderness of the tumour and fever at night, just as in cases of *bacillus coli* pyelo-nephritis.

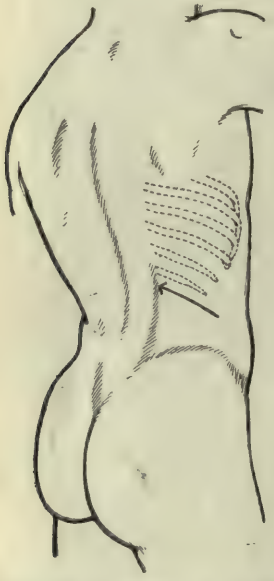


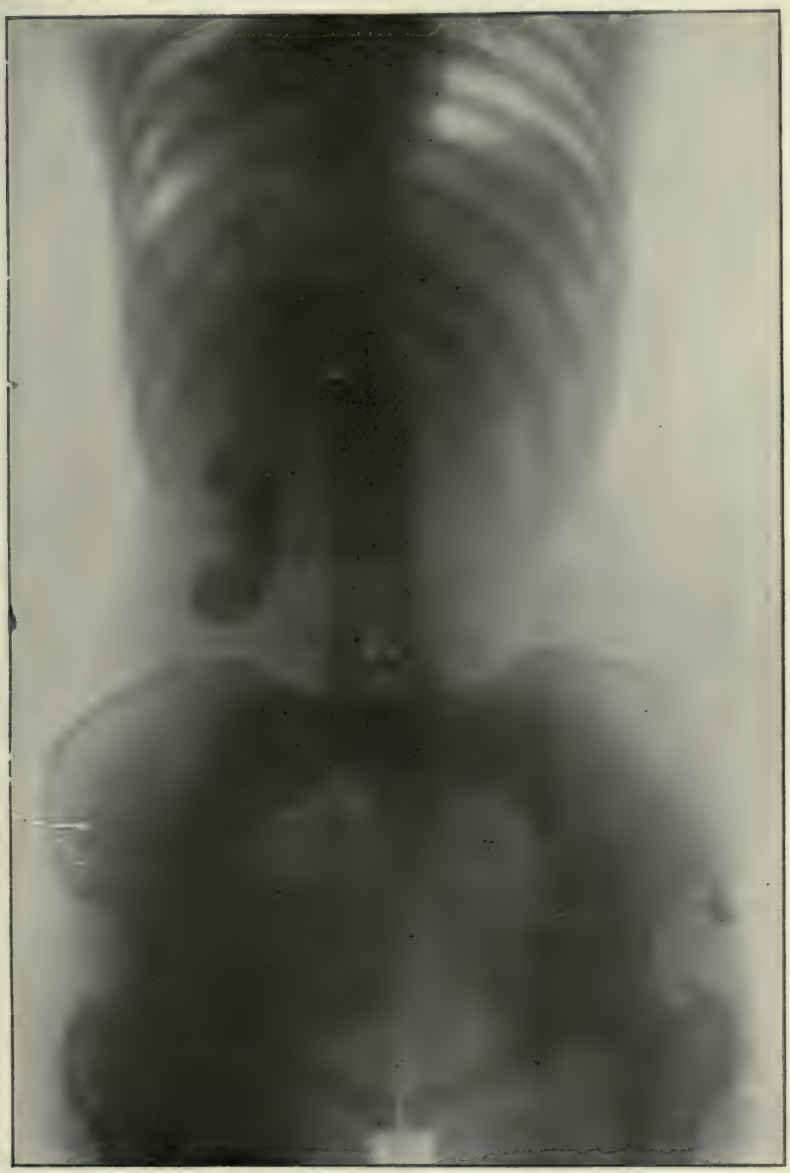
Fig. 425.—Diagram to indicate the position of incision for exposing the kidney from the loin.

Cystoscopy may reveal a diminution in force and quantity of the efflux from the corresponding ureter, or a red œdematous condition of the mucous membrane of its orifice. Energetic palpation of the suspected kidney at this time sometimes produces a slight blood-staining of the efflux, and is of great diagnostic importance if it occurs.

In many cases the clinching of the diagnosis rests entirely upon efficient and, if necessary, repeated X-ray examinations. If care is taken thoroughly to empty the colon by giving an appropriate diet and aperients, calculi ought not to be missed, and a purely exploratory operation for stone is rarely necessary. Apart from the actual diagnosis of the presence of a stone by this means, an X-ray photograph will often furnish important information which can be utilised in planning an incision for the removal of the calculus.

*Treatment.*—The pain of ureteral colic should be relieved at once by a hypodermic injection of morphia gr. $\frac{1}{2}$, followed later by another of gr. $\frac{1}{4}$ if necessary ; sometimes the paroxysms are so violent that nothing short of inhalations of chloroform will control them. When the most acute symptoms have passed off and the patient can be moved, he should be lifted into a hot bath. An application of "antiphlogistin" over a large area of the affected loin will be found very useful for the severe post-renal aching which ensues as the attack subsides.

Plate 32.



Skiagram of a stone in the left kidney. (Taken by Dr. Hugh Walsham from a case of the late Sir Henry Butlin's at St. Bartholomew's Hospital.)

Once a stone in the kidney or ureter has been diagnosed, it should be removed without any unnecessary delay during a quiescent interval. If a small stone is impacted in the terminal portion of the pelvic ureter, in that part which lies within the bladder wall itself, a few months' delay may enable the patient to pass it naturally. This is so uncertain, however, and the back pressure effects on the kidney so rapid and pronounced from obstruction in any part of the ureter, that usually it is wiser to proceed at once to the removal of the calculus.

The kidney and upper portion of the ureter are approached extra-peritoneally by a lumbar incision parallel with and $\frac{3}{4}$ inch below the last rib, the twelfth dorsal nerve being avoided and preserved in the upper lip of the incision. If the patient is a thick-set, muscular man with a deep loin, it may be necessary occasionally to resect subperiosteally the outer portion of the last rib in order to obtain sufficient room in the ilio-costal space. The kidney should be isolated from its surrounding fat and always brought out on to the loin if possible.

FIG. 426.—Lumbar pyelo-lithotomy. The kidney has been brought out on to the loin, and an incision made into the pelvis exposing an irregular roughened oxalate stone. Lobulation of the kidney along its convex border, indicating dilatation of the calyces, is well shown.

The stone may be removed by an incision either through the outer border of the kidney (*nephro-lithotomy*), or by one in the long axis of the pelvis (*pyelo-lithotomy*).

If the stones are embedded in dilated calyces, they are cut down upon through the thinned-out cortex by one or more incisions of from $\frac{3}{4}$ inch to 1 inch in length. It is never necessary to lay the whole length of the kidney open from pole to pole. If the calculus lies in a dilated pelvis, the latter should be incised over it and the wound subsequently closed by interrupted sutures of fine non-chromicised catgut. Careful suturing will prevent any appreciable risk of a permanent fistula resulting from either method, but the latter can be carried out bloodlessly, and certainly avoids a considerable

amount of damage to the already limited secreting substance of the kidney, which incision and suturing of its cortex, however carefully done, always produces.

The ramifications of the calyces can be explored through either region with equal facility by a finger, and a long gum elastic bougie (No. 4 E) passed down the ureter into the bladder to exclude the presence of another stone.

If a calculous pyo-nephrosis is found, and if the opposite hypertrophied kidney has been proved to be sufficient for the patient's needs by previous examination, it should be removed by a primary nephrectomy. An infected but only damaged kidney should be drained for a time by a tube passed into its pelvis through the cortex, bearing in mind that a permanent fistula often follows, and has to be remedied by the difficult and dangerous operation of secondary nephrectomy at a later period, when the kidney is firmly fixed by dense adhesions.

A stone impacted in any part of the pelvic ureter can be dealt with extra-peritoneally by an incision just within the anterior superior iliac spine, and parallel with the fibres of the aponeurosis of the external oblique. Even if the stone lies actually at the point where the ureter enters the bladder wall, it can usually be manipulated up into a more accessible position in the dilated proximal portion of the tube before it is actually cut down upon.

There are three important points to note in connexion with this operation :—

1. The ureter is attached to the peritoneum, and is likely to be carried inwards with the latter during its reflection from the iliac fossa.
2. It may be so dilated as to resemble a piece of small intestine.
3. If it is incised in the neighbourhood of the pelvic brim, no difficulty will be experienced in accurately suturing the incision in this position.

If the stone is impacted in that portion of the ureter which lies actually within the tissues of the bladder wall, a certain amount of prolapse of the ureter into the bladder will be seen with the cystoscope. It can best be removed by opening the bladder above the pubes and slitting up the ureteric orifice in an upward and outward direction.

Once the stone or stones have been removed, every effort should be made to deal with any bacterial infection which may be present, and which is always extremely difficult to cure.

*Bacillus coli* infections appear to react best to a mixture containing salol grs. 5 and boracic acid grs. 10, and in staphylococcic infections with alkaline offensive urine the latter should be rendered acid by the administration of urotropin grs. 10, given well diluted with water, benzoate of soda grs. 10, or acid sodium phosphate grs. 15.

In the present state of our knowledge with regard to the causation of stone it is difficult to adopt any intelligent prophylactic treatment beyond the common-sense measure of advising plenty of fluid, a suitable amount of healthy outdoor exercise to encourage free action of the skin, and regulation of the bowels.

In cases of oxaluria the ingestion of foods rich in calcium or oxalates, such as strawberries, asparagus, rhubarb, cabbage, tea, coffee, or cocoa, should be limited as far as possible. Chalky water should be avoided, and a dose of effervescing citrate of magnesia taken every morning before breakfast. There is often an associated condition of hyperchlorhydria present in these patients, and means should be taken to remedy this at the same time.

## Calculous Anuria.

Calculous anuria is the name applied to the suppression of urine produced directly or indirectly by the presence of a calculus.

For this to happen the patient must for some time have been dependent almost entirely upon the function of one hypertrophied kidney, the work done by the other being, for practical purposes, negligible. The latter may be absent altogether, or may be represented by a small knot of fibrous tissue, a fibrous sac full of calculi, or a calculous pyo-nephrosis.

Given one of these conditions, the comparatively efficient kidney is thrown out of action by the sudden impaction of a stone in its ureter, or by an attack of pyelo-nephritis superimposed upon the presence of a stone or stones in its pelvis or calyces.

Clinically the disease may be divided into three stages :—

(A) *The onset.*—If due to the impaction of a stone, the onset will be sudden and will date from an attack of ureteral colic, perhaps accompanied by hæmaturia. For the time being suppression will be complete, but later small quantities of urine may be passed during the course of the disease.

If an attack of pyelo-nephritis is the cause of the mischief, the onset is more gradual and pain is often absent. The suppression which ensues may take two or three days to become complete, but once established it usually remains so.

(B) *The quiescent interval.*—The most striking feature about these patients is the extremely little discomfort they appear to suffer during this stage, which may last from five to eight days or even longer. But there is always considerable mental anxiety aroused by the inability to pass any water, and usually a certain amount of lassitude, with headache and sleeplessness. Vomiting is unusual.

(C) *The stage of uræmia.*—This, the last stage, does not usually last more than two or three days at most. The patient rapidly passes from a condition of drowsiness into coma, the pulse becomes slow, feeble and intermittent, and the heart eventually collapses before a condition of marked pulmonary œdema. Dissolution may be preceded by convulsions.

The diagnosis once established by the passage of a catheter, every means possible is adopted to identify the sounder kidney, that is to say, the one which has been carrying on the work of excretion up to the time of the attack. It is usually possible to do this by a careful consideration of the history and physical signs, supplemented by X-ray plates and ureteric changes as seen by the cystoscope.

The sounder kidney is at once cut down upon through the loin and its pelvis opened through the cortex and drained. If the offending stone is detected easily within reach, and it can be rapidly extracted, this should be done, otherwise its removal should be left to a later date. In a few cases, owing to uncertainty in diagnosis, it may be necessary to explore rapidly both sides.

## Malignant Disease.

All solid new growths of the kidney, which are detected clinically, are malignant. Small, innocent tumours, such as suprarenal *restes*, minute fibromata, and, more rarely, small tubular adenomata, are not infrequently seen in the *post-mortem* room, but they do not cause symptoms and are of pathological interest only.

(A) Tumours of the Renal Parenchyma :—

1. Hypernephroma.

2. Carcinoma and Sarcoma.
3. Embryonic Tumours (Sarcoma of Infants).

(B) Tumours of the Renal Pelvis and Ureter :—
Villous Carcinoma.

## (A) Tumours of the Renal Parenchyma :—

### 1. Hypernephroma.

*Pathology.*—Hypernephromata form about 75 per cent. of all clinical new growths of the kidney, and although they may be found at almost any period of life, are commonly seen in patients between the ages of fifty and sixty years. They are single and originate immediately beneath the true capsule of the kidney, usually in its upper pole. In their earlier stages they are definitely encapsuled tumours, which give the impression of being perched upon the top of the kidney, rather than of being incorporated in its substance. Coarse semi-translucent fibrous septa divide the tumour into loculi, which are filled with a brownish growth showing here and there bright yellow patches, and areas of necrosis into which purple hæmorrhages have occurred. Microscopically it is impossible at the present time to place these growths in any of the ordinary groups. Their essential structure, like that of the zona fasciculata of the suprarenal gland, consists of a very delicate stroma composed of a network of capillaries, with which the cells forming the main mass of the tumour are in intimate contact. The cells vary in type, but the common one is a large, swollen clear cell, the rounded nucleus of which has been pushed into the periphery of the cell by degenerate changes in its protoplasm, and gives to the section at first sight the appearance of a reticulum.

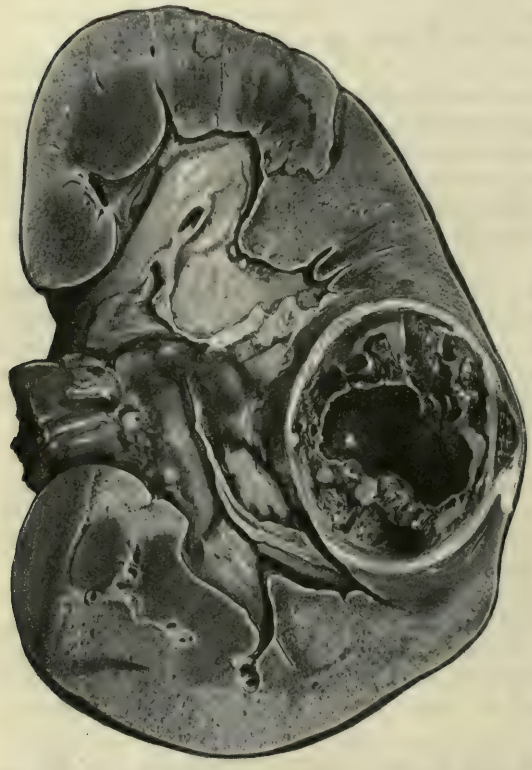


Fig. 427.—Hypernephroma of kidney. A small rounded tumour with well-defined fibrous capsule is embedded in the renal cortex. The centre of the growth is occupied by a mass of translucent jelly-like substance. (St. Bartholomew's Hospital Museum.)

It may be that these tumours are growths arising in suprarenal *restes*, the small yellow subcapsular bodies composed of developmentally included suprarenal tissue, and first described by Grawitz, or they may be true carcinomata of the renal tubules themselves (Stoerk).

1062 A

HYPER-NEPHROMA OF THE KIDNEY.
(St. Bartholomew's Hospital Museum.)

Although they are slowly-growing tumours, showing occasionally periods of months in which they appear to lie dormant, they eventually transgress their capsule, grow directly into the lumen of the renal vein and pelvis, and kill by metastases in the liver, lungs, and bones. The lymphatic system usually escapes, and it is a curious fact that secondary growths may appear,

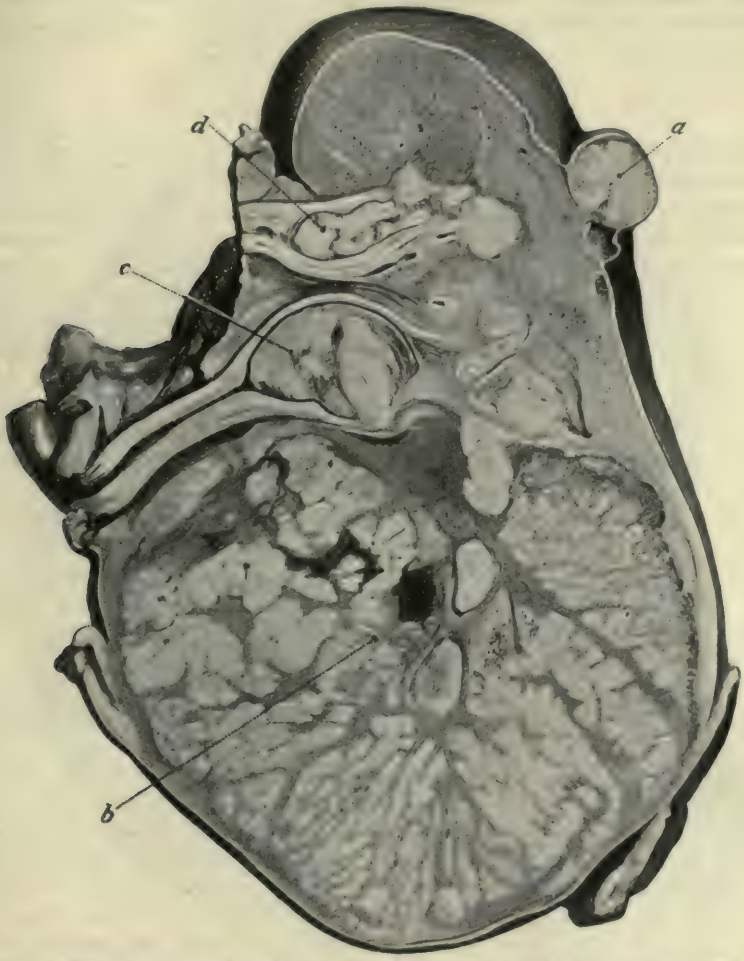



FIG. 428.—Hypernephroma of the kidney. The lower pole of the kidney is occupied by a large whitish growth which has invaded both the pelvis and the renal vein. *a*, Semi-isolated nodule. *b*, Main mass of growth. *c*, Growth completely filling pelvis. *d*, Growth in renal vein. Removed by abdominal nephrectomy from a man, aged 73, who three months previously had had an attack of hæmaturia accompanied by some colicky abdominal pain. There was no clinical evidence of recurrence five years later. (Author's case.) (Cancer Hospital Museum.)

without any signs of local recurrence, many years after a radical operation has been performed upon the primary focus.

*Symptoms and signs.*—The great symptom of hypernephromata is painless slight bleeding of the renal type. Occasionally the disease may show itself by a burst of profuse hæmaturia of one or two days' duration with ureteral pain. This clears up and may not be repeated for several months. In any case, bleeding is usually the initial symptom, and a lump in the abdomen is

not noticed until six months or more later. In a few instances the discovery of a tumour may be the patient's first warning, but this must be regarded as exceptional. The lower pole of the kidney may be palpable below the tumour, which has the usual characteristics of a movable renal swelling with a nodular surface. Pain is usually a negligible feature, and is little more than an occasional lumbar ache. There may be slight fever at night; it is important to note the possibility of this, as otherwise the suspicion of a pyo-nephrosis may be aroused.

### 2. Carcinoma and Sarcoma.

*Pathology.*—Carcinoma arising in the secreting substance of the kidney is very rare, and in the past many cases of hypernephromata have been mistaken for it. It differs essentially from the latter in that, microscopically, it has a definite fibrous frame-work, the alveoli being filled with masses or columns of cells suggestive of the appearance and arrangement of tubular renal epithelium. The growth is of a dirty-white or brownish-red colour, diffusely infiltrating the whole kidney and pelvis without at first causing much enlargement of the organ. It soon passes beyond the true capsule of the kidney and spreads chiefly by the lymphatics. Sarcomata in adults arise either immediately beneath the capsule of the kidney or in the fibrous tissue lining the renal sinus. Their macroscopic appearance is like that of a carcinoma, except that some portion of apparently healthy kidney substance is usually visible

*Symptoms and signs.*—Both these types of growth differ from hypernephromata in that a small tumour only is present with very marked symptoms. Early wasting and cachexia are the rule, and the patient rarely lives more than one year. The most prominent features are severe post-renal pain, a slight and persistent hæmaturia, and evidence of venous back-pressure or thrombosis, such as ascites, œdema of the legs, or varicocele.

### 3. Embryonic Tumours.

*Pathology.*—These tumours are found in infants of from one to three years, and, although they may be pure round or spindle-celled sarcomata, usually consist of a basis of sarcomatous tissue in which bundles of immature striped muscle and a few epithelium-lined tubules are embedded. They grow very rapidly, perhaps doubling their size in a few weeks and quickly filling up the abdominal cavity. Metastases in the liver and lungs are uncommon; a similar, but less advanced, growth may be present in the opposite kidney *post mortem*.

*Symptoms and signs.*—Their most striking feature clinically is the almost entire absence of subjective symptoms. There is apparently no pain, and hæmaturia, often absent altogether, occurs only in the later stages.

At first the child appears to suffer little inconvenience from the tumour, but later marked wasting occurs, and the patient becomes very fretful. The abdomen is enormously distended by a firm nodular tumour, and shows large dilated and anastomosing veins running immediately beneath an abnormally transparent skin. In the early stages the child may, except for the abdominal swelling, appear to be the picture of health, and the tumour may suggest a congenital cystic kidney; it is useful to remember that the latter condition is usually bilateral. The growth is a very malignant one, and is fatal in three to four months from exhaustion.

ANGIOSARCOMA OF THE KIDNEY.

The left kidney, weighing 5 lbs., removed from a boy aged 12: he has since grown up in robust health. The growth shows numerous cysts of varying sizes, containing colloid material and fibrin. It arose from the lower part of the kidney, and a thin layer of cortical substance is spread over the posterior surface for some distance. Microscopically the solid growth has a highly cellular, sarcomatous structure thickly infiltrated with red blood corpuscles. (Westminster Hospital Museum: the corresponding half in the Museum of the Royal College of Surgeons.)

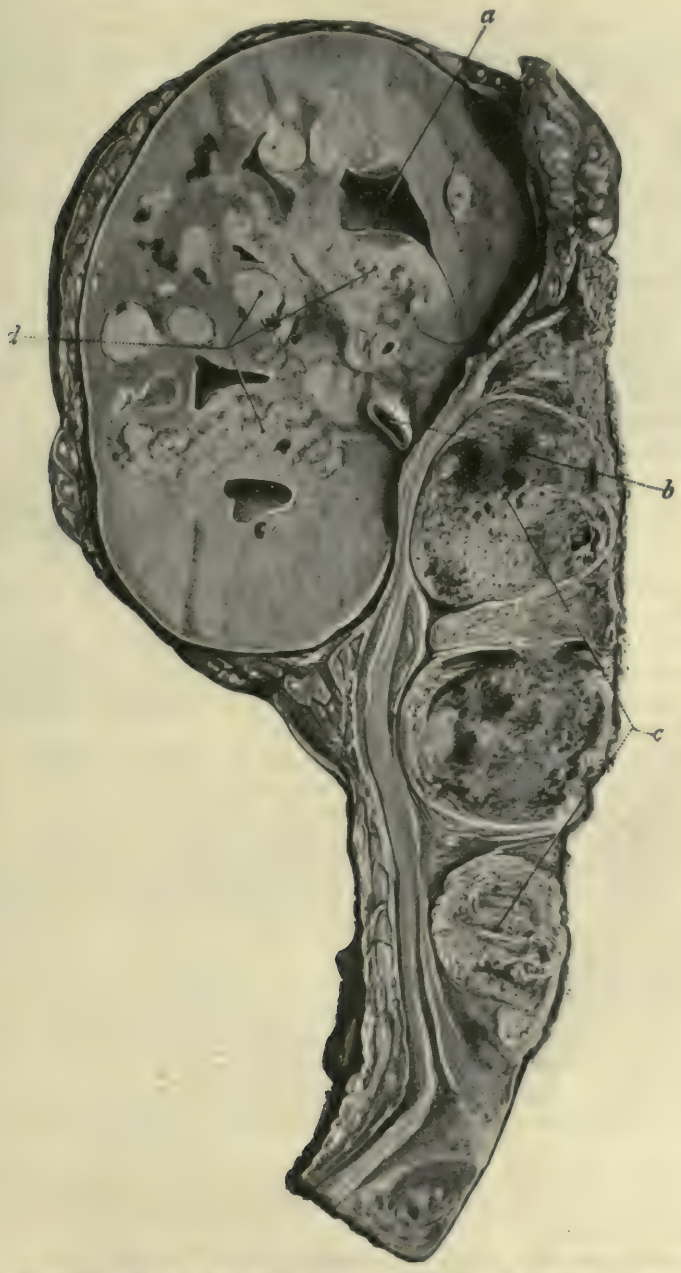



FIG. 429.—Villous carcinoma (columnar-celled) of the renal pelvis. *a*, Dilated calyx. *b*, Ureter. *c*, Greatly enlarged lumbar lymphatic glands occupied by masses of necrotic growth. *d*, Yellow nodules of the primary growth confined mainly to the pyramids and calyces. (St. Bartholomew's Hospital Museum.)

### (B) Villous Carcinoma of the Pelvis.

*Pathology.*—Carcinoma of the renal pelvis is uncommon, is a cylindrical-celled growth, and is usually of the diffuse villous type, although localised

forms have been described. It is safer to regard and treat all forms of "papillomata" of the renal pelvis as malignant for the following reasons:—

1. They all ultimately prove to be malignant if allowed to run their natural course.

2. They recur as carcinoma if removed locally.

3. They appear to infect the ureter by direct implantation, and it is not uncommon to find secondary papillomatous masses engrafted upon the lower end of the ureter and projecting into the bladder.

The growth slowly spreads by direct continuity into the apices of the pyramids, causing slight enlargement of the kidney with little if any distortion of its natural contour; masses of infected lumbar glands are seen in the later stages. The filamentous processes of the growth block the opening of the ureteric strait from time to time, and thus produce an intermitting hydronephrosis, the sac of which often contains much blood.

*Symptoms and signs.*—Hæmaturia and pain are the two great symptoms. The bleeding is free, and, although it may intermit, it is frequently almost continuous for periods of months or even years. Attacks of colicky anterior renal pain are produced by the profuse hæmorrhage and renal stasis, and, in the later stages, severe post-renal aching occurs as the growth spreads by direct continuity. There is enlargement of the kidney, and it may vary much in size and consistency from the associated hydro-nephrotic condition.

Patients so affected may survive for a surprisingly long time, and it may be only after years of almost continuous slight bleeding that the disease appears rapidly to progress, and kills by exhaustion within a few months.

*Treatment.*—The results of the treatment of malignant disease of the kidney in the past have been bad. Immediate nephrectomy is the only procedure which holds out any prospect of cure, and not only has the operation had a high immediate mortality from hæmorrhage, but also it has been followed, often within a few months, by recurrence.

Within the last few years, however, the outlook has brightened considerably, and the results will improve still further if attention is paid to the following points:—

(*a*) Early diagnosis.—Repeated attacks of hæmaturia without much pain, occurring in a patient of over forty years, should be localised with the cystoscope. If the blood should be seen coming from one ureteric orifice, the corresponding kidney should be explored without delay.

If the patient is only seen during a quiescent interval, ureteric catheterisation, by demonstrating a unilateral renal deficiency, may point to the affected side.

(*b*) A judicious selection of cases.—Excluding hypernephromata, patients with large tumours should not be operated upon except with a view to relieving symptoms.

(*c*) A complete operation.—Nephrectomy must include excision of the kidney and its surrounding fat entire in their perinephric sheath of fascia; if possible, the actual tumour is not exposed until after its removal from the body.

Hypernephromata are undoubtedly the most favourable cases. If an encapsuled tumour be removed in the way indicated above, the patient may reasonably hope for a period of three or more years' immunity from the disease, or indeed for a complete cure, as quite an appreciable number of cases has been recorded as free from recurrence as long as ten years after

operation. If metastatic deposits occur in accessible situations they should be dealt with, and, unlike ordinary forms of malignant disease, their presence

TABLE COMPARING TYPICAL CASES OF THE DIFFERENT FORMS OF MALIGNANT DISEASES OF THE KIDNEY.

| | Hypernephroma. | Sarcoma (Adults) and Carcinoma of Parenchyma. | Embryonic Tumours. | Villous Carcinoma of Pelvis. |
|---|---|---|---|---|
| Age incidence. | 50 to 60 years. | 40 to 70 years. | 1 to 3 years. | 30 to 50 years. |
| Pain. | Slight.<br>Post-renal aching. | Very severe.<br>Post-renal pain (diffuse). | Absent. | At first colicky anterior renal, later severe post-renal aching. |
| Tumour. | Large. | Small. | Very large. | Present. Varies in size due to secondary hydro-nephrosis. |
| Hæmaturia. | Usually occurs as attacks of profuse painless hæmorrhage, with often several months' intermission. | Present in large proportion of cases as slight, persistent, and almost continuous bleeding. | Usually absent. | Present. Often almost continuous for several months at a time. |
| Wasting. | Slight. | Marked. | Marked in later stages. | Marked in later stages. |
| Lymphatic infection. | Usually absent. | Usually present. | Absent. | Usually present in later stages. |
| Metastases. | Usually present in late stages in bones, lungs, and liver. | Usually present. | Not uncommon in opposite kidney and liver. | Frequently present in corresponding ureter, bladder, or liver. |
| Duration of life from time of onset of symptoms. | 3 to 5 years. | 1 year. | 3 to 4 months. | Very variable.<br>Years. |

when the patient is first seen is no contra-indication to a radical removal of the primary focus.

Survival for a longer period than one year after operation is unusual in

cases of carcinoma of the renal parenchyma or in the sarcoma of adults, but in carcinoma of the renal pelvis, if the ureter is removed in addition to the kidney, the results are distinctly more favourable. No attempt should be made to remove a renal tumour, unless of moderate size only, in an infant; survival for a longer period than one year is exceptional, and the disease is usually fatal within three or four months if the child survives the operation.

Nephrectomy is performed extra-peritoneally through a lumbar incision which can be prolonged forwards to the outer margin of the rectus sheath, and if necessary even further, the rectus muscle being retracted inwards. A preliminary survey of the renal pedicle and the abdominal contents is possible by an exploratory incision in the peritoneum, closed before proceeding with the actual removal of the tumour.

It may be found necessary to remove the suprarenal capsule in addition to the kidney, and the difficulty in securing the short capsular veins will further increase the risk. Indeed, hæmorrhage is the great trouble throughout this operation, and much time and care may be necessary in order to ligature all the large lumbar veins met with as the tumour and its surrounding fat are reflected inwards from the lumbar muscles.

## Diseases of the Bladder.

### Cystitis.

By "*cystitis*" is meant inflammation of the bladder. With the exception of those few instances in which the application of antiseptic chemical substances in the form of too concentrated solutions has proved the exciting cause, cystitis is always primarily bacterial in origin. The chance infection of the urine contained in a healthy bladder with pathogenic micro-organisms, as after the passage of a septic catheter, is not alone usually sufficient to produce cystitis, the bacteria being washed out naturally during the next act of micturition before any damage or absorption can take place. This fact has been demonstrated repeatedly by experiments upon animals; in them, it is necessary in addition to injure in some way the bladder wall, as by bruising or by inducing artificial retention of urine, before inflammation and invasion of the mucous membrane can occur. When, however, large numbers of pathogenic bacteria are repeatedly entering the bladder with each ureteric efflux, as in primary infections of the kidney with *bacillus coli* or the tubercle bacillus, this alone appears to be sufficient to determine the onset of cystitis.

Two factors then are usually essential for the production of cystitis:—

(A) Some condition producing impairment of the natural vital activity of the bladder wall.

(B) The presence of an infecting agent.

(A) *Predisposing causes.*—1. Any disease, such as enlargement of the prostate, stricture, or atony of the bladder, which prevents the latter completely emptying itself at each act of micturition. Certain organic nervous diseases, such as a transverse myelitis or tabes dorsalis, also come into this category, but here there is actually a trophic change in the bladder wall in addition. In women the residual urine occurring in cases of cystocele is a splendid medium for the growth of organisms.

2. Trauma, *e.g.*, injury to the bladder wall by the careless passage of a catheter or sound, or bruising during the course of abdomino-pelvic operations.

3. The presence of a stone or foreign body.

4. New growths of the bladder. It is unusual to find cystitis in cases of simple pedunculated papillomata, but where the change is a diffuse villous growth affecting a considerable area of the bladder wall, or in malignant disease, a sloughing condition of the growth with foul septic urine is an invariable accompaniment of the later stages.

(B) *The infecting agent.*—The commoner pathogenic organisms found in cases of cystitis may be classified as follows:—

1. Those present in acid urine: *Bacillus coli*, the tubercle bacillus, and the gonococcus.

2. Those present in neutral or faintly acid urine: *Bacillus coli* and streptococcus.

3. Those present in alkaline urine: Staphylococcus and *B. proteus*. These two organisms possess the power of splitting up urea into simpler ammonium salts and rendering the urine alkaline.

**Methods of infection.**—1. From above. Direct invasion of the bladder wall by organisms carried down to it in the stream of urine from primary renal infections by *bacillus coli* or tuberculosis.

2. From below.

(*a*) The passage of a septic catheter or instrument.

(*b*) The upward spread by direct continuity or by the lymph stream of

the mixed organisms of a posterior urethritis, or of tuberculosis or other infections of the prostate gland.

3. Primary infection of the bladder.

(*a*) Invasion of the bladder wall by *bacillus coli* or other organisms by direct spread through the walls of the large intestine.

(*b*) By the blood-stream, *e.g.*, tuberculosis (very rare).

**Pathological changes in the bladder wall.**—The mucous membrane of the bladder shows the changes usually seen in catarrhal inflammation of a mucous membrane, and secretes large amounts of thick ropy muco-pus. In very acute cases there may be extensive sloughing and exfoliation of the mucous membrane, and in the more prolonged and severe cases of tuberculosis the smooth lining of the bladder may be almost entirely replaced by a layer of easily-bleeding granulation tissue. The muscular wall undergoes great hypertrophy and contracts down, so that, in extreme cases, the bladder is physically incapable of holding more than 1½ to 3 oz. of fluid, apart from any actual irritability.

The first change seen with the cystoscope is engorgement of the vessels, those situated in the region of the neck of the bladder being most markedly affected. The mucous membrane of the trigone and surrounding parts becomes a uniform or patchy dull red, and this change in cases of primary renal infection can often be traced to the pouting and œdematous lips of a ureteric opening. The mucous lining of the bladder gradually assumes a dull, lustreless aspect, and the most brilliant illumination fails to secure satisfactory definition. Here and there flakes of muco-pus can be seen lying on its surface, and repeated irrigation may be insufficient to detach these particles. Occasionally the œdematous mucous membrane of the bladder base presents the curious appearance of clusters of small semi-translucent globular bodies heaped one upon another (*bullous cystitis*). These groups of vesicles usually show most beautiful definition, and are often mistaken for sessile papillomatous growths by the inexperienced operator.

As the inflammation subsides the interior of the bladder assumes a dull white, opaque colour, and is raised into ridges by branching and anastomosing trabeculæ of the hypertrophied inner muscular coat. The interureteric bar, in particular, becomes very prominent and is raised well above the surrounding surface.

*Symptoms and signs.*—(*a*) *Acute cystitis.*—An attack of acute cystitis begins with a feeling of suprapubic discomfort, which, within an hour or two, becomes a severe ache accompanied by an intense desire to micturate. Micturition may be as frequent as once every ten minutes, a few drachms only of cloudy urine, which in the more virulent coliform infections may be blood-stained, being passed on each occasion. Sometimes a few drops of bright blood escape with the last of the urine. As micturition is completed, the patient may suffer most acutely from violent cramp-like pains in the region of the bladder neck. Sleep is impossible, and the patient lies exhausted, awaiting with the greatest dread the next call to micturate. The mucous membrane of the bladder appears to be capable of little absorption, and, in the absence of renal infection, the temperature rarely rises above 100 or 100·5 degrees.

*Treatment.*—The patient should be put to bed at once, and entirely restricted to a milk diet. He should be encouraged to drink large quantities of barley water and the natural aperient waters to flush out the kidneys and bladder, and to render the urine as non-irritating as possible. Hot fomentations to the lower abdomen, or, better still, repeated and prolonged hot hip

baths, afford the greatest relief, and suppositories of morphia and belladonna will usually be found most useful in helping to control the pain. If the patient is suffering from want of sleep, a hypodermic injection of heroin gr. $\frac{1}{6}$ should be given without hesitation.

Occasionally autogenous vaccination appears greatly to relieve the pain, and this usually coincides with marked improvement in the temperature chart. In all probability this form of treatment does not actually shorten the natural course of the disease.

The following mixture also, administered every four hours, will be found useful :—

℞ Boracic acid grs. v.
Tinct. hyoscyami ʒss.
Inf. buchu ad ʒi.

Until the acuteness of the attack has completely subsided, instrumentation of any kind whatsoever must be most studiously avoided.

(*b*) *Subacute and chronic cystitis.*—After a few days of intense and distressing pain the symptoms of an acute attack generally subside, and may completely disappear within the course of a few weeks without further treatment; but these cases may drag on for many weeks or months with little or no improvement, if vigorous local measures are not adopted. Beyond some increased frequency of micturition and vague feelings of suprapubic discomfort the patients appear to suffer little inconvenience from their complaint. The capacity of the bladder, however, steadily diminishes, and even after all evidence of infection has disappeared the increased frequency of micturition due to the contracted bladder will remain and may prove most difficult to treat. The urine varies from an appearance of haziness only, as seen in the terminal bacillurias of the coliform infections, to the thick foul urine of prostatic and stricture cases. If the urine from one of the latter is allowed to stand, a thick tenacious mass of muco-pus quickly settles to the bottom of the specimen glass, in marked contrast to the more diffused and flocculent deposit seen in pyurias of renal origin.

When all acute symptoms have disappeared, every effort should be made with the help of the cystoscope to exclude any predisposing cause to infection. A vesical stone should be crushed and the obstruction due to an adenoma of the prostate or urethral stricture dealt with. In very old-standing cases it may be found advisable to combine the appropriate treatment of one of these conditions with suprapubic drainage and daily lavage of the bladder for a time. It is of the most vital importance, also, to identify the presence of any renal infection if it is present, as it is of little use to confine the attention to cleansing the bladder, if infected urine from a chronic pyelitis is continually entering that viscus by the ureteric openings. As is pointed out later (see p. 1124), the symptoms of primary renal infections (*bacillus coli* or the tubercle bacillus) may be almost entirely vesical, and the site of the original lesion will be missed if a careful examination of the ureteric orifices is neglected. At the same time, it should be noted that a coliform infection of the bladder may remain, and resist all forms of treatment, long after the original pyelo-nephritis has completely resolved.

In cases of chronic cystitis, excluding those due to tuberculous disease, the bladder should be thoroughly washed out once or twice daily with one of the following solutions :—

1. Boracic acid (grs. x. to grs. xx. ad ʒi.).
2. Oxycyanate of mercury (1 in 8,000 to 1 in 4,000).
3. Silver nitrate in distilled water (gr. $\frac{1}{4}$ to gr. $\frac{1}{2}$ ad ʒi.).

Boracic lotion will be found most suitable for the subacute cases, whilst in the chronic ones the best results will be obtained by employing oxycyanate of mercury and silver nitrate solutions for alternating periods of five or six days.

The following mixtures for internal administration may assist :—

1. For cases with foul ammoniacal urine :

Urotropin grs. x.
Benzoate of soda grs. x.
Infusion of buchu ad ʒi.

2. For acid pyurias :

Salol grs. v.
Boracic acid grs. x.
Infusion of buchu ad ʒi.

Autogenous vaccination is useless in the treatment of cases of chronic cystitis.

## Vesical Calculus.

*Pathology.*—The varieties, composition, and ætiology of stone will be found discussed on p. 1052.

Bladder stones are usually met with in small children and old men. In the former, they are primarily renal in origin, and although many of the small stones which pass down the ureter are voided naturally in the urine, some are arrested in the bladder, and are gradually added to in that situation. In the latter, they are composed mainly of triple phosphate, and arise in the stagnant urine present in cases of prostatic obstruction, stricture, and atony of the bladder from any cause.

Calculi may be single or multiple, and, although usually loose and free to move about in the bladder, they are sometimes found almost immovable in a deep post-prostatic pouch, or lying embedded amidst heaped-up and œdematous folds of mucous membrane.

An encysted stone is one which has been formed in a pouch communicating with the main cavity of the bladder by a somewhat narrow opening. These pouches may be congenital or acquired. In the congenital cases, the mouth of a single diverticulum lies either above and to the outer side of a ureteric opening, or, where it has arisen in a patent portion of the urachus, at the apex of the bladder. The acquired pouches are usually multiple, and are herniæ of mucous membrane which have protruded between the oblique bundles of the inner muscular coat of a hypertrophied bladder. Their openings are usually seen on the postero-lateral walls behind the trigone.

In cases of stone, the muscular coat of the bladder is usually hypertrophied, and the interior of the viscus shows well-marked trabeculation. Obstruction to the intramural portion of the ureters ensues, and leads to the production of a certain amount of fibrosis in the kidneys, which show the changes commonly seen in the ordinary form of chronic interstitial nephritis. Infection of the bladder is usually only a question of time, and after years of cystitis an ascending infection may prove fatal. In a certain percentage of these cases stones are also present in the kidneys, and predispose to a fatal issue.

*Symptoms and signs.*—One of the most constant symptoms of vesical calculus is pain, which may vary considerably in its intensity, however, in different subjects. In children it is usually very distressing, the patients screaming and pulling at the foreskin during micturition in their attempts to relieve

it. In elderly men, on the other hand, where the stone or stones may lie quietly in a deep post-prostatic pouch, little or no discomfort may be experienced. The pain usually occurs towards the end of micturition as the bladder walls grasp and force the stone onwards into the neck of the bladder. It may be felt as an intense griping sensation deep in the perineum, or may be referred to the root of the penis or frænum. It arises in the daytime when the patient is up and about, and is brought on by any jolting movement or unusual

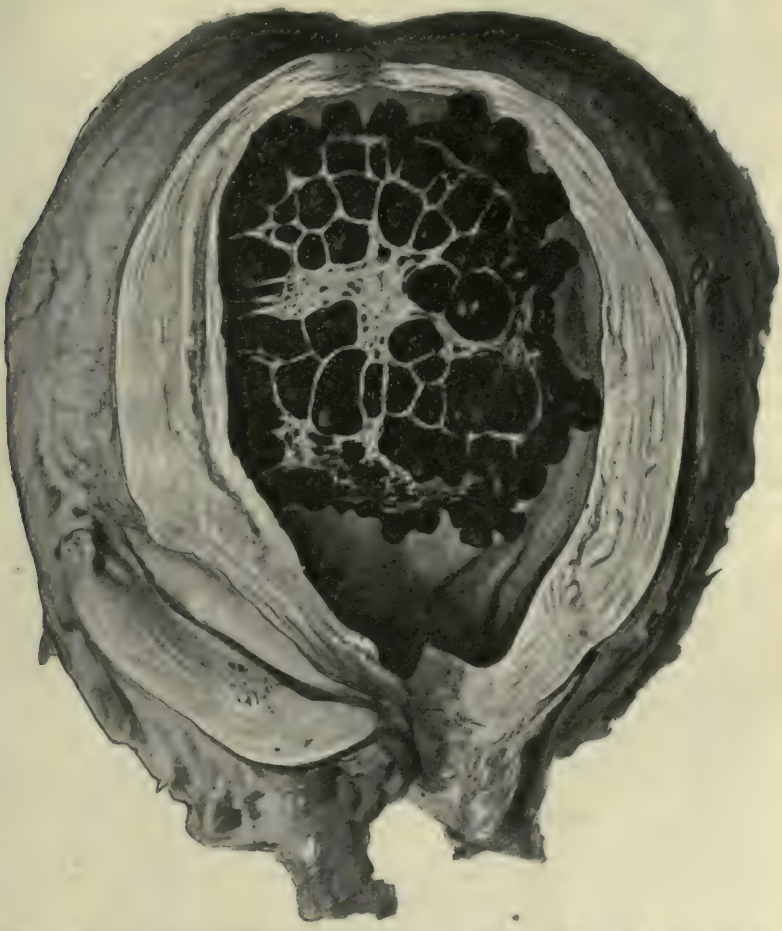


FIG. 430.—Vesical calculus. A large mulberry stone, composed of oxalate of lime, is seen almost completely filling the cavity of a much hypertrophied bladder. (St. Bartholomew's Hospital Museum.)

form of exertion. To this will be added an almost constant suprapubic ache, when infection has occurred. Hæmaturia is seldom absent for long, and recurs every few days to a greater or less extent; it is never profuse, and may only be detected on microscopical examination. In clean cases a few drops of bright blood may escape as micturition is completed, but when marked cystisis is present the whole of the urine may show a uniform dull red tinge from oozing of the congested mucous membrane.

There is usually some increased frequency of micturition, which, in aseptic

cases, may only be noticed in the daytime. Beyond some urgency, the character of micturition is unaltered, except in small children, where the stream may occasionally intermit for a few moments as a small stone engages in the opening of the urethra.

Older patients may experience little or no discomfort for periods of a few days or even weeks, and then be subject to a sharp recrudescence of their symptoms, which a few days' confinement to bed will almost completely relieve.

The diagnosis in a case of suspected stone is made by cystoscopic examination; the number of the stones present, and a very fair idea of their size and composition, may be gained in this way, and, what is equally important, the condition of the bladder wall and the presence of any pouches determined. In small male children, where the urethra may not readily admit the ordinary form of child's cystoscope, a most satisfactory investigation can be carried out by bimanual rectal examination under an anæsthetic.

Sounding at the present time is rarely necessary, as the information acquired in this way is not so accurate as that obtained by the use of the cystoscope, and an encysted stone, or one present in a prolapsed and dilated ureter, may completely escape detection by this method.

A short-beaked metal instrument (No. 5 E.) is usually employed for this purpose and a systematic examination carried out in a bladder distended with 4 oz. of boracic lotion, the patient's buttocks being slightly elevated on a pillow to enable the stone to fall away from the bladder neck. In some cases on rotating the beak of the instrument from side to side a sharp characteristic click may be both felt and heard, which will place the presence of a stone beyond all doubt.

A routine X-ray examination is essential, not so much to identify a calculus in the bladder, as to exclude the presence of stone in other portions of the urinary tract.

*Treatment.*—A stone in the bladder should be crushed or removed by some form of cutting operation. By the term "litholapaxy" is meant the introduction into the bladder of a lithotrite, the crushing of a stone, and the immediate removal of the fragments by an evacuator; whenever possible, this method should be adopted in preference to an open operation.

The results of these two procedures appear to be equally good, but whereas the patient is up and about again in two or three days after lithotrity, in suprapubic cystotomy a period of two to four weeks or even more may be required for convalescence. Moreover, although crushing is usually the more lengthy proceeding of the two, it is less likely to be followed by renal complications or severe shock, provided the patient is well wrapped up and carefully protected from cold during the whole time he is under the anæsthetic. Owing to the fact that small fragments of stone may escape the action of the evacuator and so form a nidus for the further development of calculi, it has been urged that litholapaxy is more likely to be followed by recurrence. This factor can be eliminated by cystoscoping the patient on the third day after operation, and again using the evacuator if any residual grit or spicules of stone are detected. With women, in whom crushing can be carried out very readily without any appreciable oozing, it is often possible to make a satisfactory cystoscopic examination immediately after the operation has been completed.

A stone weighing $1\frac{1}{2}$ to 2 oz., and indeed any calculus not too large to be grasped by the blades of the lithotrite, can be safely crushed, and it is rare that one is met with in England at the present day either too large or too hard for removal in this way. A stricture is as a rule no bar to the employment

Calculus in the bladder of a boy. (Skiagram taken by Dr. Hugh Walsham.)

of this method, as it can usually be satisfactorily dealt with by preliminary dilatation or urethrotomy.

In the following instances, however, an open operation is usually advisable :—

1. Cases of prostatic enlargement.—In these patients the stone may lie in a deep post-prostatic pouch, and it may be impossible to manipulate it satisfactorily within the grasp of the blades of the lithotrite. Moreover, a suprapubic operation not only serves for the extraction of the calculus, but also affords the surgeon an opportunity of enucleating the prostate either at the time or after a suitable period of preliminary drainage.

2. Cases complicated by severe cystitis.—Here also an open operation is the wiser course, as it provides free drainage, and permits of more thorough irrigation of the bladder than can possibly be carried out by means of a catheter.

3. Young male children.—The minimum age at which it is possible to employ litholapaxy depends not so much upon the age of the child as upon the size of its urethra. If due care is exercised and a suitable instrument is available, crushing can often be safely carried out in boys of eight years, or even considerably younger if the external urinary meatus is first enlarged by incision.

4. Cases of encysted calculus.—After suprapubic cystotomy it is usually possible to extract the stone after nicking the mouth of the pouch in several places. If the calculus is a large one, or if the opening of the diverticulum is narrow, it may be necessary to break up the stone into two or more pieces before it can be safely removed. A chisel and mallet are used for this purpose, the stone being pushed forwards and supported by two fingers in the rectum.

Whichever method of dealing with a stone is adopted, whether it be a crushing or a cutting operation, it is important to note that the treatment does not necessarily end with the extraction of the stone. If sepsis is present, and a moderate degree of mild cystitis is common, every effort should be made to eradicate this, if recurrence is to be effectively prevented.

The choice of the particular variety of cutting operation to be employed is to a certain extent a matter of fashion and individual taste, but in England the suprapubic route is the one almost invariably adopted. In Egypt, on the other hand, extensive use is made of lateral perineal lithotomy. In the latter country the frequency with which infection of the lower urinary tract with *bilharzia hæmatobia* occurs often negatives the employment of litholapaxy, and, as native patients often insist upon leaving hospital within twenty-four hours of operation, the perineal route is a very valuable one. The drainage obtained by this method when the patient is in the erect position is excellent, and all dressings can be dispensed with without, apparently, any grave risk.

**Litholapaxy.**—The patient being placed in the supine position, the bladder is thoroughly cleansed with warm boracic lotion (grs. x. ad ℥i.) and 4 oz. of fluid finally allowed to remain in it. The buttocks are raised on a small pillow to allow the stone to fall away from the neck of the bladder. A well-oiled lithotrite, the largest instrument the urethra will conveniently allow, is then introduced and crushing proceeded with. The beak is depressed well into the bladder base by raising the handle of the instrument and pushing it slightly onwards, and, the blades having been separated, a slight shaking movement of the operator's left hand will usually be all that is required to make the stone fall within their grasp. Two precautions are worthy of note in this connexion :—

(*a*) The lithotrite, except under exceptional circumstances, should not be

made use of as an active searcher. The instrument having been placed in a suitable position, the operator's object should be to make the stone come to the lithotrite rather than the lithotrite to the stone.

(*b*) The stone having been lightly grasped, it should be carried to the centre of the bladder before locking and making use of the screw adjustment; in this way any injury to the bladder walls will be avoided.

When by repeating these manipulations the fragments of stone have been sufficiently reduced in size, all *débris* should be removed by the evacuator, and, if necessary, crushing again proceeded with until the whole of the stone has been satisfactorily disposed of.

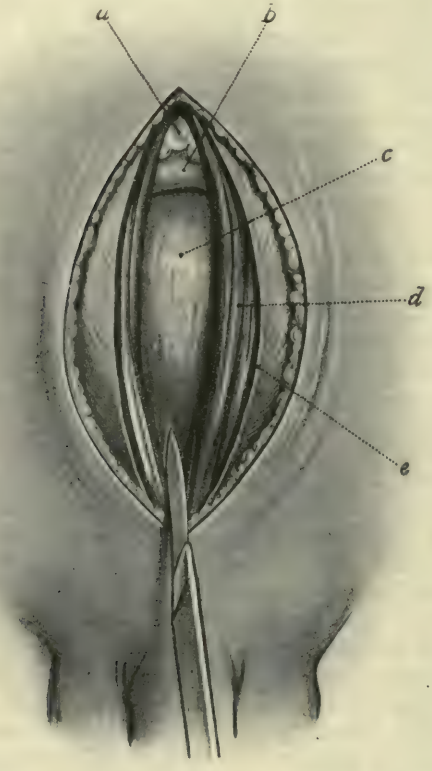



FIG. 431.—Suprapubic cystotomy. *a*, Retracted suprapubic fat. *b*, Pre-vesical pouch of peritoneum. *c*, Bladder. *d*, Rectus muscle. *e*, Anterior rectal sheath.

**Suprapubic lithotomy.**—The bladder having been washed out and distended with 10 to 12 oz. of boracic lotion, the patient is raised into a moderate Trendelenburg position. A 1½ to 2-inch median incision is made immediately above the symphysis pubis, the anterior rectal sheath divided, and the inner margins of the recti muscles drawn apart. The transversalis fascia is then incised and, a small amount of fatty tissue lying deep to the muscles having been separated, the bladder comes into view, and is at once recognised by its tenseness and dull brown colour. Several small tortuous veins can often be seen running vertically on the exposed surface of the bladder. If the peritoneum has been opened accidentally, it should be closed with a purse-string suture of chromicised catgut before proceeding further.

The bladder is opened by a backward stabbing movement of a somewhat broad-bladed scalpel, the sharp edge of the latter being directed downwards; the hole thus made is enlarged with scissors and the stone then extracted with a pair of appropriate forceps. If no marked degree of cystitis is present, the hole in the bladder wall should be completely closed with one or two tiers of non-chromicised catgut sutures. The cut margins of the anterior rectal sheath are united with catgut and the upper part of the skin incision closed, drainage of the suprapubic space being provided for by a small rubber tube passed into it through the lowest part of the intermuscular interval. A

CYSTOSCOPIC APPEARANCES.

FIG. 1.—Stone in bladder.

FIG. 2.—Adenoma of the prostate showing a well-marked intra-vesical projection ("median lobe" type), and trabeculation of the bladder.

FIG. 3.—Vesical tuberculosis. Several small yellowish submucous tubercles, one of which has softened, forming a shallow ulcer with clear-cut margin, are seen. In the foreground a somewhat gaping ureteric orifice with raised œdematous lips, situated on the summit of the inter-ureteric bar.

FIG. 4.—Tuberculous peri-ureteritis. A gaping, reddened and "dragged-out" ureteric opening.

FIG. 5.—Bilharzia hæmatobia.

FIG. 6.—Semi-pedunculated papillomatous growth of the bladder (see also Fig. 432).

catheter is tied into the urethra, and drainage continued for three to four days, or until any leakage from the suprapubic wound ceases.

## New Growths.

New growths of the bladder may be innocent or malignant.

### (A) Innocent Growths.

*Pathology.*—The only innocent tumour of any practical importance is a pedunculated papilloma, and it is usually seen during young adult life between the ages of twenty-five and forty years. Although men are more frequently affected than women, the preponderance in favour of the male sex is not nearly so great as the statistics of special urinary hospitals would appear to suggest. In the first instance, papillomata are usually single, and their favourite site of origin is the base of the bladder about ½ inch above and to the outer side of one or other of the ureteric orifices. The surface of the tumour may show innumerable small lobules packed somewhat closely together like the surface of a cauliflower, or a looser arrangement of long delicate branching filaments (*villous tumour*), which wave about in the eddies of fluid caused by the ureteric efflux, may be present. As seen with the cystoscope, they have a beautiful semi-translucent appearance, and vary in colour from a pale yellow through all the shades of yellowish-pink to a dull red. The pedicle is slender and soft, and possesses no attachment to the underlying muscle; when traction is made upon it, the stalk can be considerably lengthened by the sliding upwards into it of the surrounding mucous membrane. Microscopically these tumours consist of a central cone of delicate fibrous tissue and vessels derived from the submucous tissue of the bladder, which branches again and again into smaller vascular processes, the whole being covered by many layers of transitional epithelium.

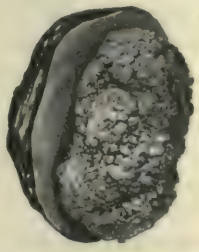


FIG. 432.—Semi-pedunculated papillomatous growth of the bladder. The tumour, together with the surrounding mucous membrane and underlying muscular tissue, was resected from the bladder base after suprapubic cystotomy. (For cystoscopic appearances of this tumour, see Plate 36, Fig. 6.)

From their position over the intravesical course of the ureter they are liable to drag upon it and produce a certain amount of obstruction, which in its turn is responsible for some dilatation of the renal pelvis and consequent symptoms.

The life history of these tumours is extremely puzzling. Even after what appears to be a satisfactory removal, they are exceedingly prone to recur within the course of two or three years—not necessarily in the scar of the previous operation, which can often be seen by the cystoscope to be healthy, but in some other part of the bladder. Indeed, they behave very much as do cutaneous warts, in that where one has been removed two may recur. The natural tendency of these growths is first to become multiple, and later diffuse over a large portion of the bladder surface, until after many years, in some cases as many as twenty, the patient dies exhausted from hæmorrhage, cystitis or renal sepsis.

At any time these tumours may take on definitely malignant characters; the underlying muscular tissue of the bladder wall is soon invaded and ansgressed, and the disease is fatal within two or three years.

*Symptoms and signs.*—The one constant symptom of papilloma of the bladder is painless hæmaturia. The bleeding may consist of a few drops of bright blood squeezed out at the end of micturition as the bladder walls contract down over the tumour, or the urine may be of a uniform smoky colour indistinguishable from that seen in renal lesions. It comes on without any obvious cause, and although it may intermit completely, it is seldom absent for long and recurs with ever-increasing severity until a condition of profound anæmia is produced. In some cases a bout of almost continuous hæmorrhage of five or six weeks' duration may occur, each amount of urine passed being deeply stained with blood.

Pain, other than a post-renal and inguinal ache produced by ureteral obstruction, is usually absent. An exception to this, however, must be made in favour of a few isolated cases in which very long filamentous processes get caught up and gripped by the internal meatus as the last few drops of urine leave the bladder. Pain is at once experienced in the neck of the bladder, or in the glans penis. Small pieces of growth may be broken off in this way, and if detected in the urine, a microscopical examination of these fragments will prove the presence of a neoplasm, but will afford no clue as to its innocent or malignant nature. Micturition is natural, and there is no increased frequency. Rectal examination reveals a soft and natural bladder base.

The diagnosis rests entirely upon cystoscopic examination, but it may be one of the most difficult clinical problems to decide upon the picture seen as to whether, in a given case, the growth is an innocent or malignant one. A reliable opinion must, in a great measure, depend upon microscopical examination of the base of the pedicle after removal, although at the time of operation the malignant character of the tumour may be recognised by the thickness and hardness of its stalk, and the difficulty experienced in lifting it away from the muscular coat of the bladder.

Speaking generally, it may be said that, in the absence of pain and induration of the bladder base, a pedunculated growth with a clean, semi-translucent, lobulated surface occurring in a patient of under forty years is likely to prove an innocent tumour.

*Treatment.*—These cases, if allowed to run their natural course, are invariably fatal from a combination of hæmorrhage and sepsis, and the only treatment that holds out any prospect of complete cure is early and free removal. The tumour can be destroyed by the diathermic cautery or excised by an open operation. Small pedunculated papillomata or multiple small recurrent buds of growth are best treated by the former method. Thorough and complete necrosis of the tumour, special attention being paid to its base, is conveniently carried out by means of an insulated wire with slightly bulbous tip introduced into the bladder through the catheter channel of an ordinary catheterising cystoscope. It is better to remove the larger or sessile growths by suprapubic operation. At the present time the ultimate results of treatment in cases of bladder tumour are rather unsatisfactory.

A fair proportion of these patients do, however, remain permanently free from recurrence, and even in those cases in which the growth reappears the symptoms have remained completely in abeyance for many years, and life is unquestionably greatly prolonged.

**Suprapubic cystotomy with excision of tumour.**—With the patient in an extreme Trendelenburg position the bladder is laid freely open above the pubic symphysis, and the edges of the incision widely separated with suitable retractors. There is always a tendency of the superior wall to bulge into the cavity of the bladder and obscure the view ; this is packed out of the way by a round

Papilloma of the Bladder.
(St. Bartholomew's Hospital Museum.)

gauze mop pushed well upwards under a retractor placed in the upper angle of the incision. If the bladder is now sponged dry and a powerful beam of light thrown into it from a head-lamp, a good view of the tumour will be obtained.

If necessary, an exuberant mass of growth is first got rid of by placing a curved Guyon's clamp on the pedicle and cutting with curved scissors on the tumour side of the instrument. The bladder is thoroughly irrigated and sponged dry and the pedicle of the tumour then dealt with. At this stage a ureteral bougie is passed into the ureter, if the latter is likely to be damaged or included in the sutures during the subsequent steps of the operation. An oval piece of mucous membrane surrounding the pedicle is mapped out by four pairs of toothed pressure forceps, and then removed together with the base of attachment of the tumour by a pair of long scissors curved on the flat. The hæmorrhage, which is usually trifling, can be controlled by sponge pressure or the temporary application of pressure forceps, whilst the edges of the mucous membrane are being brought together with fine non-chromicised catgut sutures, a few of the sutures taking up some of the deeper tissues.

The bladder may be drained above the pubes for two or three days until the urine appears to be free from clots, when the tube is removed and the wound quickly heals. In some cases it is possible to close the bladder completely, and drain by means of a catheter tied in the urethra.

### (B) Malignant Growths.

*Pathology.*—Cancer of the bladder is a disease of old age, the patients being rarely under forty and often very much older. It is unusual in women. A primary sarcoma of the bladder wall is exceedingly uncommon, and the disease is practically always a squamous- or spheroidal-celled carcinoma. It may assume any one of the following forms :—

1. A papillomatous growth with closely-set lobules, pedunculated or sessile, situated behind and to the outer side of a ureteric opening. It differs from an innocent tumour in that—

(*a*) There is usually a certain amount of sloughing present on the surface of the growth ;

(*b*) If pedunculated, the pedicle is thick and hard ;

(*c*) In the later stages, there is some invasion and induration of the muscular tissue of the bladder base.

It is a somewhat slowly-growing tumour, and is fatal in from two to five years from bleeding and sepsis. Some ureteric obstruction is common, and a pyelo-nephritis of the kidney of the corresponding side occurs early in the course of the disease.

2. An epitheliomatous ulcer or flat nodular growth with raised hard edges, usually attacking the bladder base. Infiltration of the vesicles and prostate occurs, and later, infection of the iliac and hypogastric lymph glands ; a fatal issue results in from one to three years. General metastasis is almost unknown.

3. A diffuse, sloughing villous growth involving practically the whole of the interior of the bladder, and often associated with severe cystitis.

*Symptoms and signs.*—The symptoms of cancer of the bladder vary to a certain extent with the pathological type of growth present. Whatever form, however, the disease assumes, sooner or later the occurrence of severe pain and vesical irritability serves to differentiate it sharply from an innocent growth. Indeed, the clinical picture is often that of a broken-down old man, who appears to be suffering from a persistent severe cystitis.

The pain, at first a feeling of intermittent suprapubic discomfort and strangury, soon becomes more persistent and diffuse. As the disease spreads into the extravesical tissues, the pain radiates widely down the front and back aspects of the thighs; sleep becomes impossible, and the patient has not a moment's comfort night or day.

In the papillomatous and villous types a reddish-brown discoloration from persistent oozing is seen in every specimen passed for weeks at a time, whereas a carcinomatous ulcer rarely bleeds, and when it does, gives rise to little more than a slight tinging of the urine. Per rectum, a hard plaque in the bladder base is diagnostic of malignant disease; in those cases in which an exuberant growth almost fills the bladder and there is little or no infiltration of the underlying tissues, a soft, doughy mass can often be felt on bimanual examination.

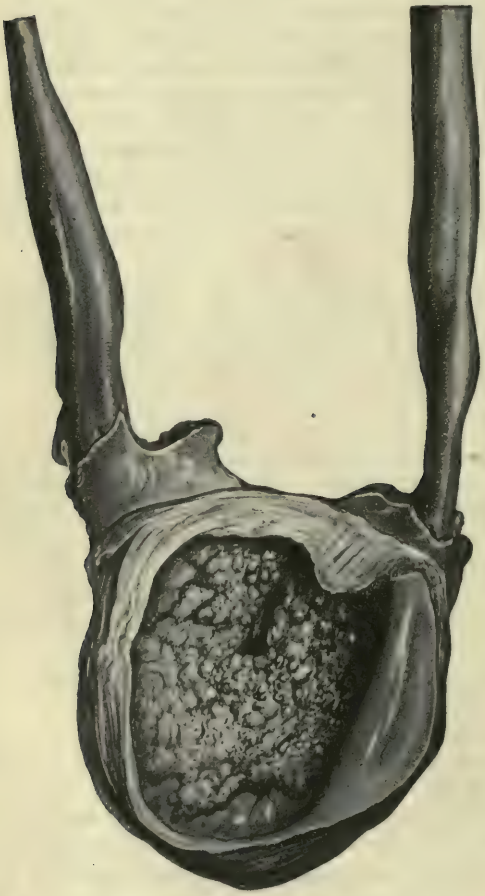


FIG. 433.—Squamous-celled carcinoma of the bladder. The growth has attacked the base of the bladder and is of the flattened nodular variety. Both ureteric openings are involved, and there is infection and marked dilatation of the ureters. (St. Bartholomew's Hospital Museum.)

In advanced cases a cystoscopic examination is unnecessary, but in any patient in whom the diagnosis is doubtful this should be done and the matter definitely cleared up. The position with regard to the ureteric openings, the type and extent of the growth, and the presence or absence of a pedicle should be carefully noted with a view to subsequent operative treatment.

Where a large, easily-bleeding, papillomatous mass almost fills the bladder details as to the character of the growth cannot be ascertained, but after careful irrigation enough can usually be seen to identify the true nature of the disease.

*Treatment.*—Every effort should be made to remove these growths widely at the earliest possible moment, because if allowed to progress the disease is invariably fatal within a few years. After many months of the most intense suffering, during which life is almost unbearable, these patients die the most miserable of deaths.

The two great difficulties met with when considering the possibility of a radical operation for carcinoma of the bladder are :—

1. The general and renal conditions of these patients, which often render them most unsuitable subjects for the performance of a serious major operation.

2. The problem of dealing with the ureters. As has been pointed out above, these growths often lie very close to, or actually involve, the ureteric openings, and it is impossible to resect them without removing the intra-mural portion of the ureter in addition.

If a small ulcer or a localised papillomatous growth is present, it is usually possible to resect it through a suprapubic wound. The tissue removed should consist of the whole thickness of the bladder wall, and be made to include at least a $\frac{1}{2}$-inch margin of healthy tissue. When the base of the bladder is involved, it will usually be found necessary to resect the intra-mural portion of one ureter with the growth. As the dissection proceeds, the ureter, identified by means of a bougie passed into it, can often be made to form a pedicle to the mass, and should be the last structure to be divided. The section is made immediately above the level at which it enters the bladder, and its proximal end is implanted into one angle of the excision wound.

In advanced cases of diffuse villous growth, the only treatment which holds out any reasonable prospect of permanent relief is to remove the bladder completely. Implantation of the ureters into some portion of the bowel or vagina is invariably followed, sooner or later, by an ascending infection, and it has been suggested that a preliminary operation for the establishment of permanent renal drainage should be carried out ten days before the extirpation is attempted. Each kidney is exposed from the loin in turn, fixed to the parietal wound, and a drainage tube passed into the renal pelvis through an incision in the convex border of the kidney (*bilateral nephrostomy*). This operation may be looked upon much in the same light as left inguinal colostomy is regarded in cases of carcinoma of the rectum.

Where a case is unsuitable for a radical operation of this nature, the symptoms will be greatly relieved for a time by opening the bladder above the pubes and removing the growth as completely as possible with the diathermic cautery.

In the later stages morphia should be freely given to control the pain, and where increased frequency and painful micturition can no longer be alleviated by drugs and daily lavage of the bladder with antiseptic solutions, a permanent suprapubic fistula should be established. If possible, this opening should be made a valvular one by bringing a cone of the bladder wall through the rectus muscle to one side of the middle line and uniting the apex of the cone to the original median skin wound on the same principle as that adopted in Frank's gastrostomy operation. The oblique fistulous tract so produced should allow little or no leakage, and the patient relieves himself by drawing off his urine at stated intervals with a soft rubber catheter passed down the fistula.

## Foreign Bodies in the Bladder.

Innumerable objects have been recorded from time to time as having been found in the human bladder, amongst which may be mentioned pieces of broken catheter, complete female self-retaining catheters, slate pencils, silk ligatures, and, more rarely, the contents of pelvic dermoid cysts. The great majority have occurred in women, and have been introduced either wilfully or accidentally through the urethra.

The symptoms are practically those of stone in the bladder complicated by severe cystitis. If the foreign body in question is a smooth object, symptoms

may be absent for a time, but infection and alkaline decomposition of the urine soon occur, and a complete coating of triple phosphate may render the object indistinguishable from a true stone. The history is unreliable in these cases, and the diagnosis is made either by cystoscopic or X-ray examination, or only after an attempt to crush the supposed stone has failed.

*Treatment.*—The foreign body should be removed without delay. In females it may be possible to seize one end of the object and extract it either with a lithotrite, or with a pair of crocodile forceps passed into the bladder through a urethral speculum. If this is not feasible, or if the subject is a male, suprapubic cystotomy is performed, and the opportunity taken of draining the bladder for a few days and dealing effectively with the severe cystitis which is usually present.

## Diseases of the Prostate Gland.

*Surgical anatomy.*—The prostate is a conical-shaped gland which surrounds the first portion of the male urethra. At its base it is structurally continuous with the musculature of the bladder, the longitudinal fibres of which can be traced downwards into the peripheral portion of the prostatic substance, where they spread out and are gradually lost. The prostate is in relation above with the anterior half of the trigone and the neck of the bladder, but the base of the gland is separated from the vesical cavity by the lining mucous membrane and muscle of the trigone, and, in the region of the internal urinary meatus, by the internal sphincter. When the prostate, however, is the seat of an adenomatous growth, the latter pushes its way upwards into the interior of the bladder and insinuates itself within the ring of the internal sphincter; thus, a thinned-out layer of mucous membrane alone separates the intravesical projection from a finger passed into the bladder through a suprapubic wound.

The apex of the gland rests upon the upper surface of the deep layer of the triangular ligament, and it is here that the urethra leaves it.

A sheet of visceral pelvic fascia, which is only deficient above where the base of the gland fuses with the bladder, encloses and firmly anchors the prostate. Laterally and behind, this sheath is a strong membranous structure, whilst in front it is looser and more cribriform in its arrangement. Running upwards in this anterior portion is the prostatic plexus of veins, the main collecting trunks of which turn backwards in the vesico-prostatic groove to drain into the inferior vesical plexus.

The prostate consists of a medulla and a cortex. The medulla contains a large proportion of the total glandular tissue, which is here grouped into a crescentic-shaped mass behind and at the sides of the urethra. The cortex is composed of fibrous tissue containing a large number of unstriped and a few striped muscular fibres, but also shows a certain number of glandular elements.

Entering the prostate posteriorly at the free portion of its base are the common ejaculatory ducts. They pass downwards and forwards, gradually converging as they do so to open into the floor of the prostatic urethra on the summit of the verumontanum. It will be noted that :—

1. The prostate shows no evidence in its interior structure of any subdivision into lobes.
2. There is no true anatomical capsule.
3. The prostatic plexus of veins lies wholly outside the gland.
4. The prostatic sheath is only deficient above, where the base of the prostate fuses with the bladder wall.

**Prostatitis: Acute and chronic.**—Inflammation of the prostate is always due to bacterial infection, and may occur spontaneously, or follow such an injury as may be caused by the careless passage of a metal catheter.

In the vast majority of the cases the infecting agent is the gonococcus, which directly invades the gland from the posterior urethra (see p. 1179).

The remainder are usually part of a cysto-prostatitis, and are due to organisms such as *bacillus coli*, staphylococci, streptococci, or *B. proteus*. They are described in the section dealing with general infections of the urinary tract (see p. 1128).

**Prostatic calculi.**—(A) *Primary calculi.*—These are small oval or rounded bodies, rarely larger than a split pea and usually much more minute, which are occasionally found embedded in the prostates of old men.

They are dark brown, multiple, and are formed from a deposit of calcium

carbonate and phosphate around the amyloid bodies normally present in the acini of the glands. If they attain any size, they gradually work their way into the prostatic ducts. The latter become dilated into small cystic spaces with mouths open towards the urethra, and the stones lie freely movable in their interior, bathed in small collections of milky prostatic fluid.

These stones may be passed per urethram from time to time, but as a rule they do not give rise to symptoms and are only discovered in the *post-mortem* room, or during the course of a routine X-ray examination.

In exceptional instances these calculi may continue to increase in size and number, until the atrophied prostate is converted into a mere bag of stones. Per rectum the gland gives an impression of irregular stony hardness, and the stones may actually be made to grate upon one another by gentle pressure with the finger.

If suppuration takes place round the embedded calculi, the abscesses usually discharge into the urethra, but may occasion considerable pain and difficulty in micturition, or even acute retention, before this occurs. In other cases the pus finds its way downwards towards the perineum and gives rise to indolent fistulæ, through which a certain amount of urine leaks from time to time. If the calculi cause troublesome symptoms or suppuration, they should be removed.

Stones which can be detected by palpation from the rectum are best extracted by exposing the posterior surface of the prostate, as in perineal prostatectomy, and incising the thinned-out glandular tissue over them. If, however, the concretions are small, and are embedded in the medulla of the prostate, the simplest method is to approach them through the urethra. The prostate is incised as in perineal prostatotomy, and the stones are then readily removed with a small scoop. The bladder is subsequently drained for a few days by a perineal tube.

(B) *Secondary calculi.*—A secondary stone is one which has passed through the bladder and become impacted in the prostatic urethra. The latter becomes dilated and the prostate hollowed out to accommodate the stone, which often attains a considerable size. Layer upon layer of triple phosphate are gradually deposited upon it, and there is a tendency for a process to form and extend downwards into the membranous urethra. Well-marked symptoms of obstruction are present, and the stone is readily felt per rectum or by a metal sound.

It can be removed by suprapubic cystotomy or through the perineum. If it is extending downwards into the membranous urethra, the latter is opened upon a Syme's staff and the stone extracted in more than one piece if necessary.

## New Growths of the Prostate.

*Pathology.*—Ninety per cent. of those enlargements of the prostate which are due to new growth are innocent in character, and consist of adenomata containing a varying amount of fibro-myomatous stroma.

These adenomata may be encapsuled or non-encapsuled.

1. *The encapsuled variety.*—The greater proportion of the adenomata, roughly 90 per cent., possess definite capsules, which they have formed for themselves out of the fibrous and muscular tissue constituting the natural stroma of the prostate. As seen in the early stages in a transverse section across the gland, an adenoma is a small yellowish body, about the size of a split pea, lying in the medulla. The common site of origin is in the interval between the converging ejaculatory ducts behind the urethra. As the

adenoma grows, it gradually forms for itself a pathological capsule by condensing the natural stroma of the gland. This capsule can be seen with the naked eye as a number of circular white strands surrounding a yellowish central body.

Soon other small adenomata appear in the neighbourhood of the primary one, and ultimately fuse together to form one mass, containing in its centre the urethra, and surrounded by a very definite laminated capsule composed of all the tissues of the condensed cortex of the prostate. The common ejaculatory ducts may also be embedded in the tumour, but are more frequently pushed aside, and lie below and behind the adenomatous mass in the residuum of the original gland.

The line of cleavage in suprapubic prostatectomy lies actually in this capsule of the adenoma, and the tumour removed consists, not of the whole prostate, but of one or more grouped adenomata containing the urethra and sometimes the ejaculatory ducts. It shows on its surface a number of circular strands of tissue derived from the pathological capsule.

The prostatic cavity, which results from this procedure, is bounded from within outwards by—

(*a*) The remaining and major portion of the pathological capsule.

(*b*) The veins of the prostatic plexus, actually embedded in or lying deep to the prostatic sheath.

(*c*) The "prostatic sheath" of pelvic fascia.

As the prostate enlarges it gradually extends in the line of least resistance, and projects backwards into the rectum, or upwards into the bladder, or in both directions.

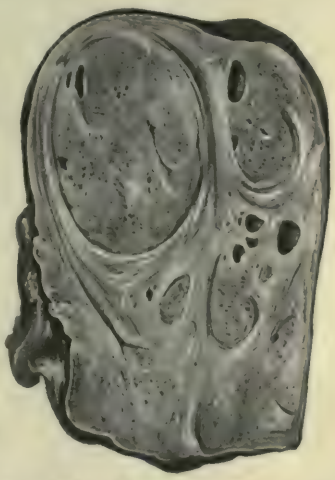


Fig. 434.—Adenomata of the prostate. Section of a prostate gland, the seat of several oval adenomatous masses. Each tumour is surrounded by the circular fibres of a pathological capsule, which has been derived from the fibromyomatous stroma of the normal gland. (St. Bartholomew's Hospital Museum.)

If two adenomatous masses are formed, lying one on either side of the urethra with the internal urinary meatus as a deep sagittal cleft between them, this is usually referred to as the "twin tumour" type. The "median lobe" is a single adenoma, which, originating in the medulla behind the urethra, forms a single tongue-like process projecting upwards into the bladder behind the internal meatus. Named from the character and extent of their intravesical projections, there are also the "collar" and "funnel" types of enlargement.

In any case in which there is marked projection upwards into the bladder a post-prostatic pouch gradually forms, and it is in the stagnant urine contained in this that alkaline decomposition occurs and secondary phosphatic stones are formed. Small dilated veins can often be seen with the cystoscope bulging beneath the attenuated mucous membrane in the neighbourhood of the internal meatus, and these vessels are often the source of the hæmaturia which occurs in some prostatic cases.

Microscopically these tumours are composed of glandular acini lying in a very abundant stroma of fibrous tissue and unstriped muscular fibres. The acini are often considerably dilated, and are lined by two or more layers of

subcolumnar cells. Their cavities contain colloid material, and may show well-marked intracystic papillary growths.

2. *The non-encapsuled variety, or "fibrous" prostate.*—This is a more slowly-growing, harder form of tumour, and the prostate very rarely shows any marked increase in size. The enlargement takes the form of a slightly-raised collar around the internal meatus. There is no definite laminated

FIG. 435.—Adenoma of the prostate gland. The bladder and prostatic urethra have been laid open from the front, and the specimen shows a "median lobe" type of enlargement with considerable hypertrophy of the muscular tissue of the bladder wall. *a*, Interureteric bar of muscle. *b*, "Median lobe." *c*, Lateral adenomatous masses. (St. Bartholomew's Hospital Museum.)

capsule as in the former type, and the adenomatous change is a more general one throughout the whole substance of the gland. Microscopically it is seen that although there has been an actual increase in the total amount of gland tissue, the fibro-myomatous stroma is relatively in much greater abundance than in the encapsuled tumours.

The changes in the bladder, ureters, and kidneys are described on p. 1038.

*Symptoms and signs.*—Adenoma of the prostate rarely causes symptoms in

men under fifty, and the cases usually come under treatment for one of the following conditions : —

(*a*) *Vesical irritability.* —In this type the patient is a man of over fifty years, who is apparently in the best of health. For some months or years he has noticed that he has had to rise once or twice in the night or early morning to pass his water. There is also increased frequency of micturition in the daytime and perhaps slight urgency, but this may often pass unnoticed. A certain amount of hesitation in beginning to empty the bladder, which is ultimately carried out with a slightly less forcible stream than formerly, is usually present. The urine is clear, and the total amount passed in twenty-four hours may be increased.

(*b*) *Acute retention.*— Acute retention may occur at any time in a patient who for some years has experienced symptoms as in (*a*) ; on the other hand, this accident may happen to a patient who previously has not noticed any change in his micturition. With the distension of the hypertrophied bladder there is much colicky suprapubic pain and straining.

(*c*) *Chronic retention.* —Here the patient is a broken-down, shaky old man, who complains that he cannot hold his water. The tongue is coated, and he usually suffers from great thirst and other symptoms of renal inadequacy. Foul urine continually dribbles away from him, giving his linen a characteristic offensive odour, or is passed in small quantities at intervals of a very few minutes.

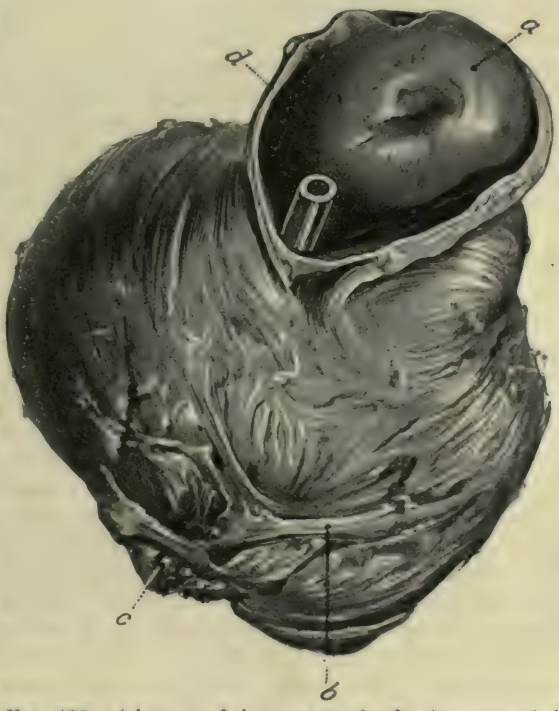



FIG. 436.—Adenoma of the prostate gland. An encapsuled adenoma of the "median lobe" type, removed by enucleation after suprapubic cystotomy. A glass rod has been placed in the prostatic urethra. *a*, Intravesical projection of middle lobe. *b*, Circular fibres of a portion of the pathological capsule. *c*, Distal end of prostatic urethra. *d*, Torn edges of vesical mucous membrane. (St. Bartholomew's Hospital Museum.)

In reality this is a case of distension overflow, with the bladder often reaching as high as the umbilicus. The muscular fibres of the bladder wall are thinned out and atrophied, and this form of distension is usually painless.

*Symptoms and signs in detail.*—1. *Increased frequency in micturition.*—This is one of the earliest symptoms of prostatic disease, and is equally great night and day, although naturally it is more noticeable during the former. A patient retiring to rest at 10 p.m. is usually untroubled until 2 or 3 a.m., after which he may have to rise every hour until he gets up in the morning.

It is difficult to find a satisfactory explanation of this symptom, which occurs quite apart from the presence of any cystitis or stone. Where ʒiv. or more of residual urine are present its interpretation presents no difficulty, but as it also occurs in cases in which the bladder is completely emptied at each act of micturition, the matter is not so simple as it appears at first sight. With the growth upwards of the prostate into the bladder a certain amount of eversion of the mucous membrane of the prostatic urethra occurs, and possibly the explanation may lie in the constant and unwonted exposure of this sensitive structure to contact with the gradually accumulating urine.

2. *Character of micturition.*—The chief characteristics of a prostatic case are the difficulty the patient experiences in beginning micturition and the fact that straining hinders rather than helps the process. Although when the desire arises the call may be a very urgent one, yet a delay of several minutes may elapse before the feeling can be gratified, and, in extreme cases, the patient may find it necessary to assume most unusual attitudes. The stream varies from one of diminished calibre only to a mere dribble, and may be intermittent. The projection is poor, and micturition may end in a dribble which continues for several minutes.

3. *Hæmaturia.*—In enlargement of the prostate bleeding of the vesical type is not an infrequent symptom, and may come on spontaneously or follow the passage of a catheter. It is most frequently seen in innocent cases. It rarely attains serious proportions, and varies between a slight general ooze from the congested mucous membrane of the trigone as micturition is completed and a fairly profuse hæmorrhage from a small ruptured vein in the mucous membrane of the bladder neck.

4. *Pain.*—Apart from acute retention of urine, pain is not a prominent feature in innocent cases, and usually amounts to little more than a feeling of fulness and weight in the perineum and a certain amount of sacral ache. Cases complicated by cystitis or stone will show the characteristic pain of these conditions, and if well-marked renal stasis is present there will be an almost constant ache felt high up in the lumbar region.

5. *Disorders of the sexual function.*—Stated briefly, the sexual changes are increased desire and a diminished power of gratifying it. In some of these patients there is, in addition, a curious upsetting of the mental balance, which results in the production of perverted ideas on the subject of the sexual function.

The above symptoms may be closely mimicked in some cases of organic nervous disease, such as tabes dorsalis, or in primary atony of the bladder, and a correct diagnosis of prostatic obstruction must be based upon a sound appreciation of the physical signs of this disease. It is wise to begin by looking for evidence of a distended bladder and for tenderness in the renal regions, as, if a rectal examination is at once proceeded with, the abdomen may be subsequently neglected. Per rectum, the prostate may be felt bulging into the anterior wall of the bowel, a slight exaggeration of the natural median groove giving the organ a bilobed character. Its natural contour is retained, and one of the most important points in the diagnosis of innocent enlargement is the preservation of its borders, especially the upper concave margin. Above the latter, unless the prostate is an unusually large one, the soft bladder base ought to be appreciated.

The posterior surface is smooth, and, in the encapsuled variety, the gland feels softer and more elastic, and is at the same time more movable than normal. In general terms it may be said that the greater the enlargement the softer and more movable is the swelling. In extreme cases, where the

adenoma may attain the size of a cricket ball, the tumour may be as freely movable as a uterus. Routine bimanual examination, under an anæsthetic if necessary, is of the greatest importance, as it is by this method alone that a true appreciation of the real size of the prostate can be obtained.

It is essential also to remember that an adenoma may project upwards into the bladder and cause marked symptoms of obstruction, whilst there is little or no evidence of enlargement to be detected from the rectal aspect.

The patient having micturated, a large Coudée catheter should be passed with the most rigid aseptic precautions, and the amount and character of the residual urine noted. The distance it is necessary to pass the catheter in before water is drawn off is some help in estimating the amount of intravesical projection. Too great emphasis cannot be laid upon the liability of the bladder to become infected in these cases at the first catheterisation, and on the importance of placing the patient in the best possible circumstances before attempting any instrumentation of the urethra.

If a short-beaked sound is employed and rotated within the bladder, some idea of the character of the enlargement can be gained, but the cystoscope is even more useful for this purpose. By slowly turning the beak of the latter instrument round in a circle just within the bladder, a very shrewd idea of the shape of the dull-red prostatic projection will be obtained; the amount of this projection is best gauged by a consideration of the depth of the shadows thrown by it into the post-prostatic pouch.

*Complications.*—The changes which ensue as the result of obstruction to the urinary outflow are described on p. 1038.

Among the more important complications arising outside the urinary system must be mentioned marked degenerative changes in the cardio-vascular system, and, as the result of constant straining, herniæ, with their attendant evils of strangulation, etc., hæmorrhoids, and complete prolapse of the rectum.

*Treatment.*—In adenomata of the prostate, when slight irritability of the bladder is the only symptom, and the residual urine is clear and amounts to ʒii. or less, no active treatment is required. Indeed, it is distinctly harmful in the early stages, and catheterisation, except perhaps on one occasion if it is required as a diagnostic measure, should be most studiously avoided. It must be remembered that if once infected, no amount of irrigation or any other form of treatment short of operation will ever render the urine aseptic again in these prostatic cases. The patient should be warned against any unnecessary exposure to cold, and against excess of alcohol in any form. If possible, he should avoid placing himself in a position in which a call to micturate cannot be responded to without considerable delay.

In the more advanced cases, when increased frequency of micturition begins to interfere with the patient's social duties and rest at night, or in which slight obstructive symptoms have culminated in an attack of acute retention, more active measures are imperative.

Two methods of treatment are then available.

(*a*) *Regular catheterisation.*—The patient should be introduced into catheter life by the surgeon himself, with every reasonable precaution it is possible to take. The difficulties and dangers of the first ten days or so having been successfully negotiated, the patient should then be taught to pass his own catheter once or twice a day according to the amount of residual urine present. He should be provided with a suitable catheter—a firm rubber one (No. 12 E.) is the safest—and this together with its accessories, oil, etc., boiled upon every occasion immediately before using. The hands and penis should be

sterilised as far as possible by the most careful washing, and, if feasible, the patient should be instructed to wear rubber gloves. The latter are required particularly where a soft rubber catheter is being used, as, though for many reasons the safest, this variety is open to the grave objection that considerable handling of it is necessary in its introduction.

If, in spite of these precautions, an attack of cystitis occurs, it should be treated by rest in bed, urinary antiseptics by the mouth, and daily lavage of the bladder with warm boracic lotion, and later, as the acuteness of the attack passes off, with a solution of oxycyanate of mercury (1 in 8,000). Suppositories of belladonna and morphia will do much to relieve the local discomfort, and for this purpose also, in the acute stage, vaccine-therapy may be useful; as a curative measure in the chronic stage vaccination is useless.

(*b*) *Operation.*—A prostatic adenoma may be removed either by the suprapubic or the perineal route. Without entering into too great detail as to the merits and demerits of these two methods, it may be said that each operation possesses certain advantages and has its own warm supporters.

In this country the suprapubic operation is the one almost universally adopted, and in spite of the earlier statistics, which appear to point to the contrary, has no greater mortality than that performed by the perineal route. Unquestionably the drainage obtained by the former method is unequalled, and probably injury to the ejaculatory ducts is more likely to be avoided. Again, in perineal prostatectomy there is quite an appreciable risk of wounding the rectum or the compressor urethræ, and epididymitis is more commonly seen as a subsequent complication.

To summarise, it may be said that encapsuled adenomata should be enucleated by the suprapubic method, and non-encapsuled tumours, in other words the small "fibrous" prostate, should be treated by perineal prostatectomy or prostatotomy.

Speaking generally, the larger and softer the prostate the easier it is to enucleate.

Where there is a marked intravesical projection of the "middle lobe," "twin tumour," or "funnel" type, or where a pronounced soft enlargement can be made out from the rectum, it can be safely assumed that the tumour is of the encapsuled variety.

If per rectum the gland shows little or no enlargement, and if cystoscopy reveals only a slightly-raised rim around the meatus (the "collar" type), difficulties are likely to be met with. In a case of this description, if the prostate feels softer than the normal organ, it should be enucleated from above, but if, on the other hand, it gives a hard, firm, unyielding sensation to the examining finger, then the best result will be obtained by perineal prostatotomy. No useful purpose is served by attempting to tear out a "fibrous" prostate with the fingers and blunt-pointed scissors through a suprapubic wound. The symptoms of obstruction are rarely relieved satisfactorily in this way, and, apart from any damage which may have been done by the roughness of the tearing process, an exceedingly troublesome suprapubic sinus is likely to follow.

**Suprapubic enucleation.**—The bladder having been distended with 8 to 10 oz. of boracic lotion, the patient is raised into the Trendelenburg position, and the bladder opened by a 1½ to 2-inch incision immediately above the symphysis pubis; it is well to make this incision as small as possible to avoid the risk of subsequent hernia. The prostate is pushed well upwards from the rectum with two fingers of the left hand wearing a glove, and enucleation is com-

menced in the middle line behind by driving the index finger of the right hand downwards into the groove which separates the intravesical projection from the post-prostatic pouch. The finger passes downwards amidst the fibres of the pathological capsule, and is made to sweep circularly round in this plane. In this way the adenomatous mass containing the prostatic urethra is completely freed except at its most dependent portion, where the urethra leaves it. The latter is broken through by a sharp jerking action of the finger and the tumour removed.

A catheter is now passed down the urethra, and the hæmorrhage checked by running through normal saline at a temperature of 115° F. The bladder is drained by a thick-walled rubber tube of $\frac{3}{8}$ inch diameter, around which the margins of the vesical incision are closed by a purse-string suture of catgut. It is not advisable to bring the bladder wall up to the deep aspect

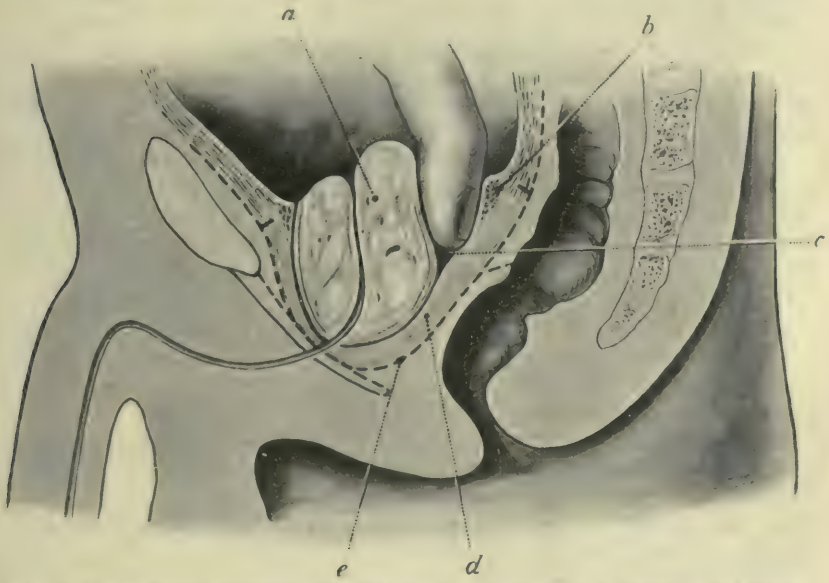



FIG. 437.—Diagram representing suprapubic enucleation of a prostatic adenoma. *a*, Adenoma traversed by prostatic urethra. *b*, Internal sphincter of bladder. *c*, Line of cleavage. *d*, Pathological capsule of adenoma. *e*, Prostatic sheath of visceral pelvic fascia.

of the rectus muscle by sutures, as this appears to delay the healing of the suprapubic sinus. In about three days' time, when clots cease to flow from the bladder on irrigation, the large tube is replaced by a smaller one, which should not be removed for at least a week. Towards the end of the third week the gradual closure of the suprapubic sinus is accompanied by the passage of small quantities of urine naturally, and, occasionally, at this time a sharp bout of urinary fever may be seen. This portends nothing serious as a rule, and, although somewhat alarming at the time, usually passes off completely in twenty-four hours. If serious hæmorrhage occurs during the first week of convalescence, it can usually be controlled by irrigation with hot normal saline containing adrenalin (soln. 1 in 1,000, str. ʒi. ad Oi.). If this fails, the prostatic cavity must be packed with a strip of gauze passed through the suprapubic wound.

**Perineal prostatotomy.**—This operation is performed by a $1\frac{1}{2}$ to 2-inch

incision in the middle line of the perineum. The membranous urethra is opened upon a Syme's staff, and a narrow-bladed scalpel pushed upwards along the groove in the staff well into the prostatic substance, but just stopping short of the bladder. The knife is withdrawn, replaced by a Teale's gorget, and finally by the finger, which forces its way onwards into the bladder through the somewhat rigid ring of the internal meatus. Drainage is carried out by a perineal tube passed into the bladder for a number of days depending upon the amount of cystitis present, and convalescence is accompanied by the passage of a large metal sound (No. 14/16 E.) at regular intervals as the perineal wound closes.

It cannot be denied that in the past men have completed happy and useful lives during the ten or fifteen years in which they were dependent upon their catheter, and have eventually died of some intercurrent malady. These cases must be regarded as exceptional. In most patients, indeed in practically all of the hospital class, catheter-life invariably means the introduction of sepsis sooner or later, which is but the beginning of the end.

Suprapubic enucleation, considering the age and general condition of the patients upon whom it is performed, is an operation of surprisingly low mortality.

It is not claimed for prostatectomy that it can actually replace the atonied muscle of the bladder wall with sound tissue, or completely eradicate sepsis which has been present often for many years, but even here it appears to work wonders. In suitable cases the relief of the obstructive symptoms is almost perfect, and the general condition of the patients improves to a surprising degree.

With the advance of medical education, the time will come when operation will be recommended with confidence to these patients as the primary treatment, and not only as a last resource to an old man worn out with years of septic absorption and loss of sleep.

It is essential, however, that a judicious selection of cases should be made and prostatectomy urged in only those instances in which it is thought that an encapsuled tumour is present, and in which renal and cardio-vascular changes have not been allowed to progress to a dangerous degree. In conclusion, it may be said that in certain instances there can be no question as to the choice of treatment; operation is essential when one or more of the following conditions are present:—

1. Pain, hæmorrhage, or obstruction, rendering regular catheterisation impossible.
2. Repeated attacks of acute retention.
3. Residual urine of such an amount that even catheterisation twice daily fails to make the patient comfortable.
4. When the patient cannot be trusted to observe rigid asepsis in the passage of his catheter.
5. Severe cystitis where bladder drainage is required.
6. Vesical stone.

## Malignant Disease of the Prostate.

### (A) Carcinoma.

*Pathology.*—Carcinoma of the prostate is of the spheroidal-celled variety, and is usually a slow-growing tumour of the dense fibrous type, which may take three or four years to kill the patient.

It is met with in old men of sixty to seventy years, but, exceptionally,

may be seen in patients as young as forty-five. It usually arises in the unenlarged prostate, but routine microscopical examination of all adenomatous masses removed by operation has demonstrated its presence as a small hard plaque in the centre of an adenoma in quite an appreciable percentage of cases.

The main direction of spread is upwards and outwards into the vesiculæ and bladder base, but it rarely perforates the mucous membrane of the latter or invades the rectum until the latest stages. For some time the fibrous prostatic sheath forms an effectual barrier, but later this limiting membrane

FIG. 438.—Round-celled sarcoma of prostate gland. *a*, Tongue-like process of growth projecting into bladder. *b*, Rod placed in rectum. *c*, Main mass of growth. *d*, Rod placed in left ureter. The patient was a child, aged three years, who came under observation for retention of urine. (St. Bartholomew's Hospital Museum.)

is transgressed, and the grooves at the side of the prostate obliterated as the growth spreads outwards towards the lateral pelvic wall.

In some cases the primary focus may still be a small hard nodule in the prostate, whilst a large inguinal mass, composed of infected iliac and inguinal glands, or secondary growths in the bones or lungs, may be already in evidence; in others the disease appears to be limited to the prostate itself for periods of many months and even years, and either metastasis appears very late, or the disease proves fatal from renal inadequacy before general dissemination can occur.

*Symptoms and signs.*—The constant feature of malignant disease of the prostate is obstruction, and increased frequency and difficulty in micturition are always in evidence. Often the patients come under treatment for

retention of urine, which, if once established, rarely intermits. Hæmaturia is unusual.

Pain is a variable symptom, and may range from a feeling of smarting deep in the perineum during micturition or a sacral ache at night to the most intense form of sciatica.

Per rectum, the prostate is usually somewhat enlarged and asymmetrical, giving an impression of stony hardness and absolute fixity to the examining finger. This change may be a uniform nodular one, or a single hard ill-defined plaque may be discovered in one portion of the gland only. With the extension upwards of the growth into the region of the bladder base, the sharp definition of the concave upper border of the prostate is gradually lost. Later, with the obliteration of the lateral prostatic grooves, the growth comes to form a densely hard flat platform beneath the anterior rectal wall over an extent as far as the finger can reach. It is worthy of note that with the disappearance of these lateral grooves a careless examination may not detect any prostatic enlargement at all.

Cystoscopic examination fails to reveal any localised intravesical projection as seen in adenomatous enlargement, and in the later stages may show a considerable heaping-up of the mucous membrane of the trigone, a condition of marked bullous cystitis being occasionally seen.

*Treatment.*—Unfortunately, the great majority of these cases are only recognised, or come under observation for the first time, at a period in the disease when any attempt at radical removal is quite out of the question. In a few carefully-selected cases extensive resection of the prostate complete in its sheath, the vesiculæ, and large portions of the bladder neck has been carried out successfully by a large perineal incision. These cases must necessarily be very few in number, because even if the extent of the disease is such as to render its removal possible, the general condition of these patients will rarely allow an operation of such magnitude to be performed. The most that can usually be done for these patients is to render their last months of life more tolerable by establishing permanent suprapubic drainage.

### (B) **Sarcoma.**

Sarcoma of the prostate is an uncommon disease, but is occasionally seen in children of from three to ten, or in adults of twenty-five to forty years. A large smooth elastic tumour felt per rectum is associated with the symptoms and signs of retention of urine. Hæmaturia and pain are usually absent.

No radical treatment is possible, and the disease often proves fatal from general dissemination before suprapubic drainage is required.

Diseases of the External Genitals.

## The Penis and Urethra.

### Phimosis.

By "phimosis" is meant such a disproportion in size between the opening of the prepuce and the glans penis that the former cannot be retracted backwards over the corona glandis. The condition is commonly congenital but may be acquired.

(A) **Congenital phimosis.**—In the congenital cases the fault lies in the smallness of the preputial orifice, which may allow a portion only of the glans to be exposed, or may be so minute that the prepuce is distended with each act of micturition. The symptoms of this condition may be divided into three groups:—

1. *Local inflammatory.*—The difficulty in retracting the prepuce leads to want of cleanliness, and hard masses of smegma collect in the groove behind the corona; in most cases there is a certain amount of constant itching and irritation. Infection occurs, and from time to time leads to attacks of inflammation which result in adhesions forming between the opposed surfaces of the glans and prepuce.

In the more severe attacks of inflammation (*balanitis*) there is much tenderness, the prepuce becomes swollen, red, and œdematous, and by gentle pressure a drop of pus can usually be squeezed out of the preputial opening.

2. *Reflex nervous disturbances.*—The local irritation may lead to abnormal sexual excitability with frequent erections, and in children to incontinence of urine.

But although phimosis may be one factor in the nocturnal enuresis of children, in most cases lack of cerebral development and control is the real cause of the evil, and the phimosis would be a negligible condition if it occurred in a patient possessing a sound and properly balanced organic nervous system.

3. *Those due to Mechanical Obstruction.*—A degree of phimosis in an adult which, under ordinary circumstances, may cause little or no trouble, during coitus may prevent the proper emission of semen. In these cases the opening of the prepuce forms a tight constricting band behind the corona of the erect organ, and produces much pain and obstruction.

In a few rare instances phimosis may produce actual obstruction to the outflow of urine, but in those children in whom this condition is complicated by congenital cystic kidneys or bilateral hydro-nephrosis, the latter must be regarded as occurring in association with, rather than as being actually caused by, the phimosis.

*Treatment.*—Stretching of the opening and gradual manipulation backwards of the prepuce may suffice for some of the milder cases, but this method is tedious and painful, and the best results will be obtained by performing circumcision in the first instance.

Care should be taken to remove exactly the right amount of skin, and it should be borne in mind that in adults the natural tendency is always to cut off too much tissue, in children too little. An appreciable cuff of mucous membrane should be left, and accurate adaptation of the skin and mucous edges secured by a sufficient number of interrupted sutures of fine non-chromicised catgut, which need not be removed subsequently. Particular attention should be directed towards getting primary union in the region of the frænum, as it is here that healing by granulation is likely to occur and result in the production of an unsightly œdematous lump of tissue.

(B) **Acquired phimosis.**—This is due to fibrous contraction of the opening of the prepuce following repeated attacks of inflammation, or to œdema and swelling occurring during an acute balanitis. It is frequently seen during an attack of gonorrhœa, and seriously militates against the successful treatment of the disease. Moreover, a patient possessing a long foreskin is more likely to contract some form of venereal disease than a normal individual. Diabetes, carcinoma of the penis, and soft sores are other causes of balanitis, which may lead to phimosis of an exceedingly troublesome character.

*Treatment.*—Cicatricial contraction of the prepuce should be treated by circumcision. If acute balanitis is present, attempts should be made to clear up this condition by baths and syringing under the prepuce with antiseptic

Fig. 439.—Method of reduction in a case of paraphimosis.

lotions before operation. During an acute attack of gonorrhœa the prepuce should be slit up along the dorsum for the time being and circumcision deferred until a later and more favourable date.

Diabetic cases should be treated by methods of ordinary cleanliness and dusting powders such as aristol, and not by operation.

**Paraphimosis.**—The term "paraphimosis" is applied to the condition in which, a naturally tight foreskin having been retracted beyond the corona, it is found impossible to replace it over the glans penis. In children it is usually the result of a simple mechanical accident, whereas in adults it is more often seen following an attack of balanitis.

The retracted prepuce quickly swells, and forms an œdematous semi-translucent roll of tissue immediately behind the corona. In the deepest part of this ring is a constricting band, which, if the condition is untreated, may

produce ulceration or even extensive sloughing of the glans. Usually before this can happen fissures appear in the superficial surface of the œdematous prepuce, and the pressure of the deep constricting band is relieved naturally by a process of ulceration.

A paraphimosis ought to be reduced as soon as possible and later, when the œdema has subsided, circumcision performed.

To reduce this condition the operator sits facing the patient and grasps the penis immediately behind the swelling with the index and middle fingers of both hands, passed from the side above and below the organ. At the same time pressure is made upon the glans with the tips of both thumbs and the prepuce gradually drawn forwards over it.

If it is found impossible to effect reduction by this simple means, the constricting band must be incised as a preliminary measure. To do this a sharp-pointed tenotomy knife is passed from in front under the dorsal portion of the band. The blade is passed lateralised, and then, the cutting edge having been turned towards the dorsum, all resisting structures are divided by a series of small nicks.

### Carcinoma of the Penis.

Carcinoma of the penis is of the squamous-celled variety and attacks old men, the patients rarely being under fifty. It is usually associated with phimosis, and it is stated to be unknown in Jews. The initial lesion is situated on the dorsal aspect of the corona, more commonly beginning on the glans than on the prepuce, though in either case both are quickly infiltrated. The corpora cavernosa remain immune for a considerable time, their strong fibrous sheath protecting them from invasion.

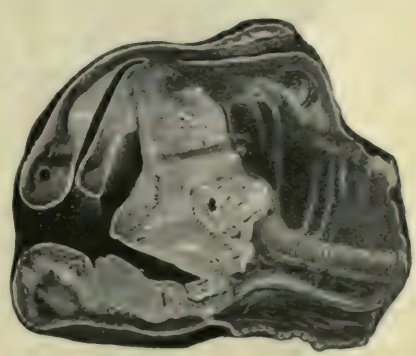


FIG. 440.—Squamous-celled carcinoma of the penis. Sagittal section of the distal portion of the penis showing almost complete destruction of the glans by a white, opaque, malignant growth. The prepuce, both above and below, is extensively infiltrated. (St. Bartholomew's Hospital Museum.)

Cancer of the penis is often preceded by a small wart, an excoriated patch or other source of chronic irritation. The disease runs a somewhat slow course, and the growth may have been in existence many months before the patient comes for treatment. As usually seen, it is a hard sessile, papillomatous mass, but may form a foul crateriform ulcer with undermined prominent edges and indurated base.

In advanced cases, when ulceration has become well established, there may be considerable pain, and there is usually a foul blood-stained purulent discharge continually escaping from under the prepuce. As the urethra is seldom invaded, micturition is not affected.

Glandular involvement occurs early and is extensive, both the superficial and deep inguinal and the iliac glands being involved. It is a noticeable feature that if the infection is bilateral the enlargement of the glands of one side is usually far in excess of the other. Metastases, other than those found occasionally in the pelvic organs, are very uncommon.

The diagnosis would present no difficulty if the growth were fully exposed, but, with the marked phimosis which is often present, a hard chancre under

the prepuce in a patient of advanced years may easily be mistaken for it. In doubtful cases the prepuce should be slit up before amputation is performed.

*Treatment.*—Amputation at the earliest possible date, combined with the removal of the glands of both sides, whether enlarged or not, is the best treatment. The penis should be divided from $\frac{3}{4}$ to 1 inch behind the growth, and as when there is recurrence it is usually in the glands and not in the stump, this should be regarded as the operation of choice. Complete amputation of the penis with its crura is an operation with a high mortality, and is often followed by extensive sloughing of the loose tissues of the scrotum and perineum. It should be reserved for cases of local recurrence, or for those very extensive cases in which, although there is no hope of a permanent cure, it is considered desirable to remove a large, foul, sloughing mass, and leave the patient with a perineal opening rather than an unsatisfactory fistula at the peno-scrotal junction.

In all cases in which it is reasonable to hope for a permanent cure an extensive flap operation should be performed upon the glands in both groins, taking particular care to secure the deep femoral gland which lies in the crural canal. It is better to do this a week or ten days after the amputation, as by this method septic infection of the large wounds in the groins is more likely to be avoided.

## Stricture of the Urethra.

*Pathology.*—Stricture of the urethra may be due either to a fibrous cicatricial change in the wall of the urethra (*organic stricture*) or to spasm of the compressor urethræ muscle (*spasmodic stricture*).

1. *Organic stricture.*—The commonest site for a fibrous stricture is the most posterior part of the bulb immediately superficial to the true triangular ligament, but it may occur in any portion of the spongy urethra. With the exception of certain rare cases in which stricture has followed a cutting and tearing operation for the removal of a "fibrous prostate," the prostatic urethra is never affected.

A prolonged gonorrhœal urethritis of several years' duration is responsible for the great majority of fibrous strictures, and in these cases the lesion is usually a multiple one. Most cases of gleet are kept up by small localised granular patches in the walls of the spongy urethra, where the gonococcus or the organisms of a secondary infection may lie dormant for months or even years. These patches are composed of sub-epithelial masses of small round cells, and the gradual development of a stricture in these situations is due to their conversion into adult fibrous tissue.

The change may be a very localised one (*annular stricture*), or may extend for some distance along the wall of the canal (*tubular stricture*). If part only of the circumference of the urethra is affected a localised infolding of the wall occurs at this point, producing a sickle-shaped projection into its lumen.

Trauma as a cause of stricture comes next in order of frequency. A workman falling astride of a beam may rupture his urethra, or the latter may be torn at the bulbo-membranous junction in fractures of the pelvis. A certain amount of extravasation of urine follows, which if improperly treated may result in the formation of an intractable stricture. The resulting fibrous tissue is often so dense that its consistency becomes almost that of cartilage.

Suppuration in the perineum following urethral disease or venereal ulceration just within the external urinary meatus are also responsible for a small percentage of the cases.

Thickened layers of epithelium at first render the surface of a stricture smooth and shining, but later this epithelial covering is shed as its nutritive supply is cut off, and actual ulceration ensues. The surface becomes rough and is covered by a layer of easily-bleeding friable granulation tissue, in which a deposit of calcium salts may occur.

The urethral wall behind the stricture becomes thinned out and dilated, and the patient, utilising all the force of a powerful hypertrophied bladder, may suddenly rupture it. Extravasation of urine follows, and may travel widely, limited only in its extent by the anatomical connexions of the triangular ligament and Colles's fascia to one another and to the pubic arch. Usually, however, the leakage of urine is more gradual in onset.

Ulceration of the dilated urethra allows of the escape of organisms into the tissues of the perineum, and a periurethral abscess is formed. This may discharge into the urethra and heal, but the pus more commonly finds its way to the surface and gives rise to a urinary fistula in the perineum.

A squamous-celled carcinoma may arise primarily in the undamaged urethra, or at the site of an old fibrous stricture, and may produce stenosis of the canal, but these cases are very rare.

The changes which ensue in the bladder, ureters, and kidneys are described on p. 1038.

FIG. 441.—Fibrous stricture of the bulbous urethra. A tubular stricture with marked fibrous thickening of the urethral wall can be seen at *a*. The bladder is much hypertrophied. (St. Bartholomew's Hospital Museum.)

2. *Spasmodic stricture.* — Spasmodic stricture is due to spasm of the compressor urethræ muscle, and is not a stricture in the ordinary sense of the word. The careless passage of a cold, improperly lubricated bougie or catheter may produce this spasm in the normal urethra, but, as commonly seen, it is a complication of gonorrhœa or of a fibrous stricture, brought on by errors of diet or enforced delay in micturition.

Reflexly it may be produced by any operation upon the mucous membrane

of the anal canal, as in the ligature of piles, or by any procedure which involves manipulation of the spermatic cord, as in the radical cure of hernia or varicocele. Retention following abdomino-pelvic operations is due not so much to spasm of the compressor muscle as to actual interference with the musculature of the bladder itself.

*Symptoms and signs.*—Stricture is usually seen in men of twenty-five to forty years of age, some three to ten years after the first attack of gonorrhœa. Almost the only symptom is the alteration in micturition, a gradually increasing difficulty, extending over a period of months, having been noticed. Straining helps in the initiation of a stream, which, although of poor calibre, possesses a natural or increased force of projection. The column of urine usually loses its revolving character and may spray out laterally, finally terminating in a prolonged and characteristic dribble. If the stricture is actually at the meatus the stream may be a forked one. A low chronic form of infection of urethra and bladder is common, and produces a slight whitish discharge noticed at the meatus in the morning, and increased frequency of micturition with perhaps some suprapubic discomfort or painful straining. The diagnosis is confirmed and the site of the stricture determined by examination with olive-headed bougies or the endoscope. With the latter instrument, after inflation of the urethra with air, a typical stricture is seen as a white septum with a dark glistening spot, concentrically or eccentrically placed, representing the narrowed lumen of the canal.

*Treatment.*—The best treatment for stricture is gradual dilatation by olive-headed bougies. Operation may be essential in certain instances, but, in the ordinary case, it must be regarded as merely constituting a rapid method of carrying out the initial stages of the treatment. Urethrotomy must be followed by a prolonged course of bougie treatment if relapse is to be guarded against, and the ultimate results are no better than those obtained by dilatation alone.

**Gradual dilatation** is carried out by the passage of bougies twice weekly until the stricture will admit easily a full-sized metal sound (12/14 E.), when the frequency of the sittings is gradually decreased until, at the end of two years, the patient may hope to be completely cured. No force must be used in employing this method, as any tearing of the overlying mucous membrane or rupture of the stricture defeats the object of the treatment. At each sitting bougies of gradually-increasing calibre are employed until a size is reached that actually fits the stricture, when it is left in position for two or three minutes. A few days later, under ordinary circumstances, the stricture will be found to be so relaxed that bougies one or even two sizes larger than the maximum employed on the previous occasion can be readily passed. Great care must be exercised to avoid making false passages by tearing the mucous membrane with the point of the bougie. Free bleeding will result from this, and the operator can easily prove to himself that this accident has occurred by gently attempting to withdraw the bougie. If the instrument is actually engaged in the stricture it will be gripped, and a certain amount of pull will be necessary to free it, whereas if the point lies in a false passage it will slip back readily without requiring any appreciable effort to withdraw it.

**Indications for operation.**—In practice it will be found that operation is rarely necessary, and it is only indicated in those cases in which treatment by gradual dilatation is impossible because—

1. The stricture is so tight that no instrument can be passed (*impassable stricture*);

2. The passage of bougies produces great pain and spasm, or is constantly followed by hæmorrhage or rigors;

3. The stricture is so dense and hard (*fibro-cartilaginous stricture*) that no impression can be made upon it;

4. The stricture is an elastic one (*resilient stricture*), and no permanent relaxation can be secured;

5. Time is an essential feature in the treatment.

Division of a stricture can be carried out from within the lumen of the urethral canal by an instrument called a urethrotome, *internal urethrotomy*, or by an open operation through the perineum, *external urethrotomy*. The results of these two operations, in uncomplicated cases, appear to be equally good if followed by careful and prolonged after-treatment. But, by the former, the period of convalescence is materially diminished, and the patient is spared the great inconvenience of a temporary urinary fistula. Again, in stricture of the penile portion of the urethra, a permanent fistula is almost certain to follow operation by the open method. In internal urethrotomy, all that is essential is that it should be possible to pass the filiform guide of the urethrotome. The staff will follow this into the bladder, and the roof of the stricture is then cut from before backwards. At first sight it is difficult to understand why simple incision of the stricture should produce such permanent good results, provided that care is exercised in the after-treatment. The explanation lies in the fact that when, after incision, a full-sized metal sound (No. 12/14 E.) is passed, the cut in the roof of the urethra is opened up, the ends of the fibrous ring widely separated and a new splice of healthy tissue brought into the gap so formed. This condition of affairs is rendered permanent by tying in a rubber catheter (No. 8 E.) for the first seven or ten days following operation. The two grave objections which have been urged against internal urethrotomy in the past have been septic absorption from the wound and serious hæmorrhage coming on within twenty-four hours of operation. Sepsis can be avoided by a judicious selection of cases and by adopting external urethrotomy where bladder drainage is required; hæmorrhage by using a modern urethrotome. In Walker's modification of Maisonneuve's instrument the groove which carries the knife ends at the bend of the staff, and so prevents any injury to the prostate, which is usually the source of any serious bleeding. If, in spite of these precautions, hæmorrhage does occur, it can be effectively controlled by passing a large rubber catheter (No. 16 E.) stretched over a well-lubricated stilette, withdrawing the latter, and applying a firm pad and bandage to the perineum.

External urethrotomy, however, still has an assured position in the surgery of the disease, and will be specially called for in—

1. Impassable strictures;

2. Strictures complicated by fistulæ, or extravasation of urine, where perineal bladder drainage is essential;

3. Fibro-cartilaginous strictures far back in the perineum;

4. Cases complicated by severe cystitis.

### Complications of Stricture and their Treatment.

1. **Acute retention of urine** (see p. 1103).

2. **Cystitis.**—Most old-standing cases of stricture have a very chronic bacterial infection of the bladder, which will not interfere with the carrying out of treatment on the ordinary lines as indicated above. In the more acute and severe cases of cystitis, however, external urethrotomy should be per-

formed, and a drainage tube passed up through the proximal dilated portion of the urethra into the bladder from the perineal wound. The bladder should be drained for seven to ten days by this method, and washed out daily with a solution of oxycyanate of mercury (1 in 8,000).

3. **Epididymitis.**—A patient suffering from stricture and an infected urethra is subject to acute attacks of epididymitis, usually unilateral, which may come on spontaneously but more often follow the passage of bougies or catheters. There is a small amount of effusion into the vaginal sac, but the testicle quiets down in a few days without suppuration. It is wise to defer any active form of treatment of the stricture until the attack has subsided.

4. **Periurethral abscess and urinary fistulæ.**—A small periurethral abscess may burst into the urethra and cure itself spontaneously; more frequently it forms a circumscribed tender swelling of varying size in the perineum which, if left to itself, will make its way through the skin and form a urinary fistula. It should be incised in the perineum, and after drainage has been established by a tube for a week or ten days the stricture is dealt with by external urethrotomy. The essential part of the treatment of all fistulæ is the division of the stricture. This should be done by the open method, and all fistulous tracks thoroughly laid open, scraped and packed with gauze at the same time. If thorough division of the stricture has been carried out, daily baths and careful dressing will result in sound healing of the fistulæ in the course of a few weeks.

5. **Extravasation of urine.**—This dangerous condition may result in one of the following ways:—

(*a*) As the result of straining, the dilated urethra proximal to the stricture may rupture suddenly with sharp cutting pain in the perineum.

(*b*) The extravasation may arise more gradually as a cellulitis spreading from a periurethral abscess in the perineum.

(*c*) It may follow a gangrenous urethritis arising in a patient of any age without necessarily any evidence of stricture. This form of urethritis may occur in badly-nourished male children, but in adults is usually preceded by some form of chronic infection of the urethra.

Limited behind and laterally by the attachment of Colles's fascia to the base of the triangular ligament and rami of the pubic arch, the foul urine spreads forwards in the loose cellular tissues of the scrotum and penis on to the anterior abdominal wall. In extreme cases it may even extend up in the superficial fascia of the chest wall to the axillæ. Rarely, if the membranous urethra is involved, it may track widely in the pelvic cellular tissue surrounding the bladder.

The patient looks, and is, profoundly ill, with a raised temperature and a very frequent or even a running pulse. The infiltrated tissues are swollen and tender, and covered by œdematous dusky-red skin. Bullæ containing purulent serum or gas are often present, and large areas of skin may slough, completely exposing the testicles and deeper tissues of the penis.

*The patient must be operated on without delay if his life is to be saved.*

A median longitudinal incision is made in the perineum and deepened until Colles's fascia has been incised, and the superficial perineal space opened up. If the hole in the dilated proximal urethra can be found, it is enlarged and a perineal drainage tube passed upwards into the bladder, but no time should be wasted in searching for it.

Numerous vertical incisions are made into the cellular tissue of the perineum, scrotum, penis, and abdominal wall over the whole of the infiltrated area and

the patient swathed in sheets of cellulose or compressed moss fibre. These incisions should be about 1½ to 2 inches in length, and should extend down to the deep fascia. No tubes are employed, and better drainage is secured without gauze packing. Stimulants are given freely, and the patient is lowered into a hot bath from time to time, a careful watch being kept upon the pulse. The stricture is dealt with later by external urethrotomy.

## Retention of Urine.

By the term "retention" is meant the collection of urine in the bladder, which gradually becomes distended, and is unable to empty itself owing either to some obstruction in the outflow or loss of muscular power in the bladder wall itself. This condition must be carefully distinguished from suppression, in which the bladder is empty, and the fault lies in the kidneys, which are unable to secrete any urine.

Retention of urine may be acute or chronic.

Acute retention occurs in gonorrhœa and retroversion of the gravid uterus, or follows operation, where up to the time of the onset of the acute symptoms the urinary system has been healthy. In other cases, as in stricture or enlargement of the prostate for example, the kidneys, ureters, and bladder may already show well-marked back-pressure changes, and the treatment of these patients must be approached with much greater caution.

In these acute cases there is much cramp-like suprapubic pain, and the bladder rarely rises much beyond a point midway between the pubes and the umbilicus.

Chronic retention occurs in some cases of innocent or malignant enlargement of the prostate, in certain organic nervous diseases such as tabes, and in primary atony of the bladder. The bladder can often be felt to extend as high as the umbilicus, but there is no pain beyond a certain amount of suprapubic discomfort. The urine dribbles away almost continuously, or is passed in quantities of a few drachms at a time at frequent intervals (*distension overflow*).

These patients complain of not being able to hold their water (*false incontinence*), and are fully convinced that each act of micturition completely empties the bladder.

In any case of retention, whether acute or chronic, if there is reason to suppose that the kidneys are suffering from the effects of back-pressure, it is unwise to evacuate rapidly large amounts of urine with the catheter. It is safer to relieve the distension gradually by drawing off 15 to 20 oz. at four-hourly intervals after the patient has become thoroughly warmed in bed.

If this procedure is not adopted, suppression of urine may follow in a small percentage of cases. The actual cause of this is not quite clear. It may be that, the pressure in the renal pelvis having been too suddenly relieved, blood pours into the kidney, which becomes greatly engorged and strangled in its own capsule. On the other hand, many of these cases are associated with a quiet pyelo-nephritis, which sudden interference in this way may determine into acute suppurative nephritis.

## Some of the Commoner Causes of Acute Retention of Urine and their Treatment.

1. **Tight phimosis and pin-hole meatus.**—Either of these two factors may be the cause of acute retention in the newly-born infant, but in practice this

condition is rarely met with. In suspected cases it is usually found that the child, unknown to its parents and nurse, has been passing its water naturally in the bath.

A small meatus should be incised with a sharp-pointed tenotomy knife in a downward direction, and, in phimosis, the opening of the prepuce dilated with sinus forceps. If dilatation does not suffice in the latter instance, the child should be circumcised, the presence of any hydro-nephrotic or cystic condition of the kidneys having been excluded by careful examination before the operation is undertaken.

2. **Impacted calculus in the urethra.**—This occurs only in males, and is by far the commonest cause of acute retention in boys of five to fifteen years. The stone is readily detected on palpation, or by the use of a metal sound. It is commonly impacted in one of the following situations :—

(*a*) *At the external urinary meatus, which is the narrowest part of the urethra.*—The meatus is incised towards the frænum, and the stone is then easily removed.

(*b*) *Far back in the perineum in the membranous or beginning of the bulbous urethra.*—An attempt is first made to push the stone back into the bladder, and, failing this, it is cut down upon the perineum by a small median incision, the urethra opened and the stone extracted.

If it can be pushed back into the bladder, it is then crushed and the fragments washed out with an evacuator. In many cases a full-sized evacuator alone will suffice without the use of a lithotrite.

(*c*) *Immediately behind the corona glandis, in the narrow portion of the urethra proximal to the fossa navicularis.*—The meatus is incised towards the frænum to give more room, and an attempt made to extract the stone with a pair of narrow-bladed urethral forceps combined with manipulation from behind with the fingers. It is advisable to give a general anæsthetic for this purpose, as it often proves a difficult and trying procedure for both surgeon and patient. If it is found impossible to secure a firm grip of the stone in this way without tearing and damaging the urethral mucous membrane, it should be pushed back into the perineum and dealt with as in (*b*).

3. **Gonorrhœa.**—Retention is seen towards the end of the first or during the second week of the attack as the infection spreads back into the bulbous urethra, and is due to spasm of the compressor urethræ muscle.

A dose of opium (tinct. opii, m. xx.) should be given and the patient placed in a hot hip-bath. If this fails to relieve him in fifteen minutes, the urethra should be gently irrigated with warm boracic lotion (grs. x. ad ʒi.), and after anæsthetisation by the installation of ʒi. ss. of a 5 per cent. solution of novocaine, the urine drawn off by catheter.

A rubber catheter (No. 6 E.) should be chosen and thoroughly lubricated with warm sterile oil, not with glycerin.

If these precautions are adopted no difficulty will be met with, and the risk of any bladder infection following catheterisation is negligible.

4. **Hysteria.**—This form of acute retention occurs in highly-strung nervous girls of seventeen to twenty-five years. Every effort should be made to make the patient pass her water naturally, because if once relieved by a catheter it may be very difficult to persuade her to do without its use for some days or even weeks. A hot bath and smart saline purge are useful adjuncts.

5. **Stricture.**—Acute retention of urine in a case of fibrous stricture is due to spasm of the compressor urethræ, and congestion and œdema of the urethral mucous membrane. It is brought on by excess of alcohol, exposure, or enforced delay in micturition.

The patient should be given a sedative (tinct. opii m. xx.) and induced to pass his urine in a hot bath. This method is often successful, the urine slowly dribbling away, and a smart saline purge and rest in bed for twelve hours will often complete the cure for the time being.

If these means are unsuccessful, no time must be wasted, and an attempt made to pass an instrument, a well-varnished silk-web catheter lubricated with warm oil being most suitable for the purpose. It is well to begin with one of the larger sizes (No. 7 or 8 E.), and then gradually to work downwards until one is found which will pass through the stricture. Even if no catheter can be passed, it is usually possible to insert and tie in a filiform guide for twelve hours, which enables the urine to trickle slowly past the instrument. By this time relaxation of the stricture will probably have been secured, and the surgeon will be able to pass a small-sized catheter. Another method which can be adopted is to make use of a "railroad" catheter. A filiform bougie is first passed through the stricture, and then a small-sized catheter threaded over it and pushed onwards into the bladder.

If all these methods fail, the bladder must be aspirated.

*Aspiration of the bladder.*—The distended viscus having been clearly identified by palpation, a long aspirating needle is pushed into it at a point ½ inch above the symphysis pubis. The point of the needle is directed backwards and slightly downwards, and, the bladder having been entered, the urine is allowed to trickle slowly away.

If a bladder has been aspirated it must on no account be allowed to become distended again, as there is always some danger of leakage from the puncture hole into the suprapubic space.

As a rule, before a second aspiration is required, the stricture will be found to be passable, but, if necessary, the process can be repeated two or three times. More than this is inadvisable, and if the patient is still unrelieved, an external urethrotomy should be performed, although a certain amount of risk will always be attached to the operation as performed at this time.

If for any reason it is not possible to operate at once, a long, slightly-curved trocar and cannula are plunged into the bladder immediately above the symphysis. The trocar is then removed, a rubber tube passed into the bladder through the cannula, and the latter withdrawn over it. Temporary drainage of the bladder can be secured in this way until, a week or ten days later, some operation for the relief of the obstruction can be more conveniently carried out.

6. **Retroverted gravid uterus or impacted uterine fibromyoma.**—The bladder is at once relieved by catheter, and if rest in bed for a few days does not allow the pregnant uterus to right itself, it is forcibly replaced under an anæsthetic. A fibroid of the uterus is dealt with on ordinary surgical lines.

7. **Prostatic enlargement.**—The actual cause of retention in many cases of adenoma of the prostate is uncertain, but it probably depends upon a combination of circumstances, of which acute over-stretching of the already weakened muscular fibres of the bladder and spasm of the compressor urethræ are important factors.

The patient is placed in bed in a warm room, and a fair-sized catheter passed with the most rigid aseptic precautions. Usually no difficulty will be encountered in carrying this out, and the most satisfactory catheter to use is a Porge coudée (No. 17 or 20 F.). If attacks of retention have occurred repeatedly before, or if it is known that for some time a considerable strain has been thrown upon the kidneys, the distension is relieved gradually, not more than 15 oz. of urine being drawn off at any one time.

### Urethral Shock and Urethral Fever.

Urethral shock is a rare condition and is the term applied to certain symptoms which come on synchronously with, or within a few seconds of, the passage of some instrument into the deeper portion of the urethra. It is in all probability due to some reflex nervous disturbance, and may occur in cases in which a sound has been passed with the greatest gentleness. In the very few instances which have terminated fatally no abrasion or tear in the urethral mucous membrane has been found. Immediately after the passage of the instrument the patient shivers slightly and feels faint. He is blanched and sweating, with a rapid, feeble pulse and sighing respiration. The temperature is usually subnormal, and the patient presents all the appearances of profound shock.

If he is put to bed and stimulants are given, he usually recovers completely in the course of a few hours.

In urethral fever, on the other hand, the symptoms are definitely due to some septic absorption from a lesion in the urethra. It may follow the passage of a sound in the case of stricture or prostatic enlargement, or may arise spontaneously with the first natural passage of urine over an internal urethrotomy wound. It is also not infrequently seen about the end of the second week after prostatectomy, when, with the gradual healing of the suprapubic wound, a certain amount of infected urine passes naturally. The symptoms appear within two or three hours of the exciting cause, and begin with a certain amount of headache and chilliness, which soon passes into a very definite rigor.

The temperature rushes up to 103° F., sometimes even to 105° F., and then in a short while falls rapidly, leaving the patient exhausted, cold, and sweating profusely. The pulse is rapid and feeble, and the patient looks very ill, his face being of a peculiar ashen-grey colour.

Within a few hours, beyond a feeling of general malaise and distaste for food, recovery is complete, and the attack may not be repeated. Rarely, the rigors and high temperature continue day after day, until the patient is completely exhausted, and death occurs from suppurative nephritis or septicæmia.

During such an attack the patient should be confined to bed and given three doses of the following medicine at intervals of three hours :—

℞ Quininæ hydrochlor. grs. 5.
Tinct. opii, m. x.
Spirit. vini Gallici, ʒi.
Aquam, ad ʒiv.

Subsequently, treatment is directed towards the clearing up of the urinary sepsis which is invariably present, and, if possible, any manipulation of the urethra is avoided for the time being.

## The Scrotum.

**Epithelioma of the scrotum,** often called chimney-sweep's cancer, from the frequency with which it occurred in chimney-sweepers owing to the irritation of the soot, generally begins as a dark wart or tubercle, which ultimately ulcerates, producing a sore with hard sinuous everted edges, and an irregular warty base. In some instances ulceration is delayed and the cancer takes the form of a cauliflower-like out-growth. At times it begins as a chronic

eczema. The irritant appears to be not merely the carbon of the soot, but one or more of the products of the destructive distillation of coal, as the cancer does not occur from soot produced by the burning of wood, and is found amongst workers in coal-tar and its products. The inguinal glands become enlarged from invasion by the epithelial growth, but the disease does not, as a rule, affect internal organs. The testicle may occasionally become involved, when the lumbar glands will be, sooner or later, affected. Death is commonly due to the exhaustion and sepsis produced by the ulceration in the inguinal glands, or hæmorrhage from the opening of a large blood-vessel in the groin.

*Treatment.*—Free and early excision of the primary growth with removal of the inguinal glands on one or both sides is necessary, although the disease is one of the less virulent forms of carcinoma. If the testicle is involved it should be excised at the same time. The skin of the part is very lax, and although the testicle may be denuded, it can be easily covered in.

Fig. 442.—Elephantiasis scroti in a Fiji Islander. (Weight 90 lbs.) Copied by kind permission from Dr. J. B. Hamilton's article in the "International Text Book of Surgery."

**Elephantiasis scroti** (Fig. 442) is an enormously hypertrophied condition of the skin and connective tissue of the scrotum, the result of filariasis (see p. 90). The scrotum may enlarge to the size of the head, or hang down to the knee as a pear-shaped tumour, or, larger still, may touch the ground, and the patient have to move with the mass supported on a go-cart or wheelbarrow. The swelling consists of œdematous fibrous tissue in which may develop cysts or multiple abscesses, and contains two cavities, the *tunicæ vaginales testis*. As the tumour grows the testicles attached by the remains of the gubernaculum testis are likewise pulled down and the cord is enormously lengthened. The fluid in the tunica vaginalis may be serous or chylous, or it may become purulent. The skin is rugous, ulcerated, or may leak lymph or chyle (lymph scrotum). The penis is dragged down and urine dribbles out of a depression on the front of the mass. The progressive enlargement is frequently added to by intercurrent attacks of inflammation.

*Treatment.*—A time is selected when the patient is free from fever and the mass is elevated, *e.g.*, by means of pulleys, for some hours. An elastic band is then tied tightly round the base and kept from slipping forwards by metal

pins transfixing the pedicle. Flaps of healthy skin are turned up, the penis and testicles are dissected out, and the mass cut away. The vessels are tied and a dressing of gauze packed temporarily between the flaps over the testicles and penis which soon become covered with skin.

## The Testicle and the Spermatic Cord.

### Imperfect Migration of the Testis.

The testis is originally formed near the caudal extremity of the kidney. From here it migrates during intra-uterine life to the scrotum. The exact causes of this change of position are not known, but the muscular fibres of the *gubernaculum testis* play an important part. The term *monorchid* is applied to a male with only one testis in the scrotum. This condition is not due to one testis alone being present in the individual except in very rare instances, but to imperfect migration. Bilateral *cryptorchidism* is usually associated with bilateral imperfect development of the testes, and consequent non-development of adult male characteristics in later life. Both testes should have migrated by the end of the ninth intra-uterine month well into the scrotal bag. The passage may, however, be delayed, and testes have been known to descend as late as puberty. In its progress the testis may be arrested, or it may pass out of the normal line and into an abnormal position. The latter constitutes *ectopia.* Imperfect migration, particularly arrest, is attributed to a number of different causes, which are chiefly concerned with imperfections of development. There may be a want of proper union of the Wolffian duct with the mass which becomes the body of the testis; the vas may be too short, the testicular vessels may not be sufficiently elongated, and the testis thereby may be held up. In ectopia, the pull of other than the normal muscular fibres of the *gubernaculum testis* may be the primary factor.

Arrest of the testis may be classified thus:—

1. Abdominal arrest.
   - (*a*) Lumbar. (This position is the only one which can be rightly termed "undescended" testis, for in all other positions the organ has travelled somewhat.)
   - (*b*) Iliac.
2. Inguinal arrest.
   - (*a*) High.
   - (*b*) Low.
3. Inguinal-scrotal arrest.
   - (*a*) Pre-pubic.
   - (*b*) High scrotal.

Ectopia of the testis may be classified thus:—

- (*a*) Perineal.
- (*b*) Femoral.
- (*c*) Superficial inguinal.
- (*d*) Cruro-scrotal.
- (*e*) Pre-penile.

The arrested testis is frequently also an imperfectly developed testis. The commonest place for an ectopic testis to be found is in the perineum by the side of the anus. In this migration the testis having missed the entrance

into the scrotum is dragged into this position by those gubernacular fibres which are attached to the tuber ischii. After leaving the inguinal canal the testis may also pass into the upper part of the thigh, the femoral testis. When a testis passes outwards on to the superficial surface of the aponeurosis of the external oblique muscle, the position may be termed superficial inguinal. In all cases of arrest or ectopic testis the scrotum itself is fully developed on both sides. The side from which the testis is missing is developed but has not been distended.

Imperfect migration of the testis, whether of the nature of arrest or ectopia, may be associated with the following pathological conditions :—

1. Inflammation.
2. Hydrocele.
3. Hernia.
4. Torsion of the spermatic cord.
5. Malignant disease.
6. Dermoid cyst.

Inflammation may be due to similar causes to those which produce it in the properly placed organ. The inguinal and the perineal testes, however, are more prone to injury because they cannot so easily get out of the way, hence traumatic inflammation is common in them. Repeated attacks of orchitis of this type damage the testis, render it quite useless and constitute a valid reason for its removal.

Gonorrhœal inflammation of a testis retained in the right iliac fossa may be mistaken for appendicitis, but absence of a testis in the right side of the scrotum should make the diagnosis clear.

A hydrocele frequently forms around an imperfectly descended testis. Sometimes it is bilocular. If a testis is retained within the abdomen, the processus vaginalis testis may have passed into the scrotum, and a hydrocele may form there, and may be thought to be the missing testis, but fluctuation, translucency and the absence of sensation should make the nature of the swelling evident.

Hernia is very commonly associated with both arrest and ectopia of the testis. Probably in 80 per cent. of both of these conditions there is an accompanying patent processus vaginalis testis, and into this potential sac abdominal contents may descend. When a hernia is present, its significance overshadows that of the mere imperfect descent of the testis, and treatment should primarily be directed to the hernia rather than to the testis.

Torsion of the cord of an imperfectly descended testis sometimes occurs as the outcome of some violent muscular effort, and particularly where the testis is arrested in the inguinal canal. The signs and symptoms produced are similar to those of a strangulated inguinal hernia (see p. 1110).

Malignant disease of an arrested testis is believed to be more common than a neoplasm of a normally placed organ, but this is questionable. A dermoid cyst has been found within the tissue of imperfectly descended testes, particularly in animals.

The *treatment* of imperfect descent of the testis is of distinct importance, for an ill-placed testis may be a life-long worry to its possessor. It is, however, very doubtful whether a testis which is brought into the scrotum by artificial means and remains there, really undergoes functional development.

An arrested or ectopic testis may be left where it is, it may be transplanted

into the scrotum, it may be replaced within the abdominal wall, either into the peritoneal cavity or into the extra-peritoneal tissue, or it may be removed.

It is wise to leave the testis alone if there appears to be any attempt on the part of nature to cause its further migration. Such cases can be left alone. In this connexion it must be remembered that the testis is quite easily withdrawn in infants from the scrotum into the inguinal canal by the cremaster muscle and particularly so if the fingers of the examiner are cold. When a hernia is co-existent with imperfect descent, operation is called for, chiefly in order that the hernia may be cured, and an attempt should be made at the same time to place the testis in its proper bed.

Orchidopexy, as the operation for placing the testis within the scrotum is called, should not be carried out before the child has learnt ways of cleanliness. Sometimes it is quite easy to bring the testis down into the scrotum, even with but little tension upon the cord, but the organ has a great tendency to pass up again nearly or completely into the position which it occupied before operation. A number of different manœuvres have been adopted to secure fixation in the scrotum. The testis, freed as far as possible say in the inguinal canal, has a passage made for it down into the corresponding half of the scrotum. It may be brought actually through the scrotal wall, and allowed to remain outside the bag for a day or so and then be pushed back into the scrotal tissues to which it has become adherent, and the skin sutured over it. At other times the testis is attached temporarily to the inner side of the thigh after it has been brought out through the scrotal wall. Another plan is to carry the imperfectly descended testis down into its own side of the scrotum, and then pass it through a slit in the septum of the scrotum and leave it lying against its neighbour in the opposite half of the bag. Where a testis cannot be brought down into the scrotum, and a hernia exists with it, provided that the testis on the other side is normal, the best plan is to remove the testis and cure the hernia.

Where both testes are arrested an attempt should be made to preserve each of the organs, as the combined internal secretion of the two may be the determining factor in the bodily and masculine development of the individual.

In short, the treatment of an arrested or an ectopic testis depends largely upon the position in which the testis is found. If it is within the abdominal wall, it should be left alone. If it is in the inguinal canal, it is seldom that it can be brought down into and held in the scrotum, and it may be best to remove the organ, and close the patent processus vaginalis. If the testis is in the perineum, it can always be transplanted into the scrotum, since it has gone further than it need and its cord is of good length.

## Torsion of the Spermatic Cord.

Torsion or twisting of the spermatic cord with rotation of the testicle is a rare disease and is usually associated with some developmental error.

There are three predisposing factors :—

(*a*) Abnormal position of the testicle. The large majority occur in cases of imperfect descent, the testicle being commonly in the inguinal canal. In this position the organ is more liable to be influenced by muscular strains.

(*b*) Abnormal mobility of the testicle. Owing to the persistence of the fœtal *mesorchium* or mesentery the testicle possesses greater freedom of movement in the vaginal sac.

(*c*) Abnormal suspension of the testicle. The gland is situated within the scrotum but lies with the long axis horizontal. The cord is flattened

and triangular in shape, its apex at the external ring, its base formed by its spread-out attachment to the testicle. The main group of spermatic veins passes upwards from the globus major on one side of the triangle, the vas from the globus minor on the other.

The *exciting cause* of torsion is usually some sudden muscular effort, but such a simple movement as crossing the legs whilst in a sitting position may be sufficient to produce it.

The obstruction to the venous return in the cord produces great engorgement of the vessels of the testicle. The latter swells up and hæmorrhages into its substance occur. Owing to the rigid character of the *tunica albuginea*, pressure necrosis of the body ensues and may be followed by suppuration.

*Symptoms and signs.*—The attack begins with sudden severe pain in the testicle and lower abdomen, and vomiting. There is profound shock, and, as the patient gradually recovers from this, the vomiting ceases, and the temperature, at first subnormal, and the pulse frequency rise. In the inguinal canal or neck of the scrotum is a globular, tense, exquisitely tender lump. The skin over it is red and œdematous. The swelling is irreducible and there is no impulse on coughing.

The symptoms closely mimic those of a strangulated hernia, but, in torsion, the constipation is not absolute and the corresponding side of the scrotum is empty. Difficulties in diagnosis may also arise in gonorrhœal and other infections of a retained testicle.

*Treatment.*—Immediate operation is essential. The swelling is exposed by a free incision and the cord untwisted. In the case of a testicle situated in the scrotum, presumably, therefore, a functioning and useful organ, every effort should be made to save it. If there is no great enlargement from extravasation of blood into it and the vessels of the cord are not thrombosed, the testicle should be anchored in the scrotum and the latter drained by a tube for forty-eight hours. If, on the other hand, the testicle is much damaged or the spermatic vessels thrombosed, it should be at once removed. Excision is the best treatment for those cases occurring in the small and ill-formed testicles of imperfect descent.

## Varicocele.

A varicocele is a dilated condition of the veins of the spermatic cord. Issuing from the upper pole of the testicle the veins pass upwards, mainly on the anterior aspect of the cord, as a freely communicating plexus—*the pampiniform plexus*—to the external ring. Here they resolve themselves usually into three main trunks, two lying in front and one behind the cord. The spermatic veins are formed by the junction of these veins in the neighbourhood of the internal ring, and end, the left in the left renal vein, the right in the inferior vena cava ; they are provided with one or more valves.

A varicocele is usually limited to the pampiniform plexus (*scrotal varicocele*), but the dilatation may extend to the internal ring (*inguinal varicocele*).

There are two main varieties :—

(*a*) *The primary or congenital type* is found in young males between puberty and twenty-five years of age. It occurs on the left side only in the great majority of cases.

The complete development of the left testicle is delayed, as shown by its later descent into the scrotum, and it appears to be a fact that the numerous small veins in the fœtal cord do not disappear so completely on the left as on the right side ; but there is really no satisfactory explanation of why the left side only should be affected in so many cases, or indeed, for that matter,

why dilatation should occur at all. If the condition were a bilateral one, a comparison with the dilated and engorged state of the spermatic plexus in certain animals during the rutting season might be suggested.

The body of the testicle on the affected side is frequently smaller and softer than normal; this may be due to atrophy, but is more probably a fault of associated imperfect development.

(*b*) *The secondary or acquired type* may occur on either side or at any age, but as it is due to back pressure effects of an abdominal tumour, commonly malignant disease of the kidney, it has a rapid onset and is not usually seen in men under forty.

*Symptoms and signs.*—In many cases there are no symptoms, and this is noticeable when a varicocele is present in young athletic men in perfect health.

In the tall, overgrown and less sturdy type much pain may be complained of and may be associated with a hypo-chondriacal mental attitude. The pain is of an aching character, is worse after long standing and when the patient is tired, and is particularly noticeable in hot climates. It is felt in the groins and back. If some thrombosis has occurred, local pain is experienced in the cord itself.

The scrotum is thin-walled and pendulous, and the tortuous thick-walled veins of the varicocele, together with a certain amount of spontaneous movement communicated to them by the hypertrophied cremaster, makes the usual description of "feeling like a bag of worms" a very apt one. The swelling in the scrotum looks and feels exactly what it is—a mass of dilated veins. There is a thrill but no true impulse on coughing, the swelling disappears at once when the patient lies down, and when the cord is compressed at the external ring and he assumes the erect position, fills up again from below.

*Treatment.*—Very few cases of varicocele require any treatment at all, and as it is rare to see the congenital type after the age of thirty, it is fair to assume that the condition disappears spontaneously. If there is pain and discomfort, these can usually be completely relieved by cold baths in the morning, attention to the bowels, healthy outdoor exercise and the wearing of a scrotal suspender.

Operation should be reserved for those cases suffering from severe neuralgic pain not relieved by these simple means, for cases of thrombosis and for those patients desirous of entering one of the public services. During the late war the former stringent army regulations were relaxed to some extent, and even candidates for entrance into one of the military colleges were passed as "fit," if the varicocele was not so extensive as to hang down in a bunch below the level of the testicle.

The operation for varicocele is performed in the inguinal canal (*inguinal or high operation*), or just below the external ring (*low operation*).

1. High operation. In this, the inguinal canal is opened as if for hernia and, the sheath of the cord having been incised, the two anterior venous trunks are carefully isolated and ligatured in their continuity with fine silk.

2. Low operation. The spermatic cord is exposed by a small incision through the smooth skin over the external ring. The venous plexus on the front of the cord is isolated as completely as possible, an inch or more resected and, after ligature, the two cut ends sutured together with silk.

The former operation is the simpler and better, and the scar is approved by the members of the various examining boards. There is no risk of recurrent hæmorrhage or of a vaginal hydrocele appearing later—a hydrocele being a common complication of the low operation. In the latter it is difficult to

isolate the veins completely, and cremaster muscle with lymphatics and nerve filaments are often included in the ligatures. The results of both operations, as regards the relief of pain, are surprisingly good.

## Hydrocele.

A hydrocele is formed by a collection of serous or fibrino-serous fluid either in the tunica vaginalis, or in that portion of the processus vaginalis which, if development had proceeded along normal lines, would have been obliterated after the descent of the testicle. Why, under certain circumstances, the natural fluid secreted by the endothelial lining of the vaginal sac accumulates and is not absorbed is not known.

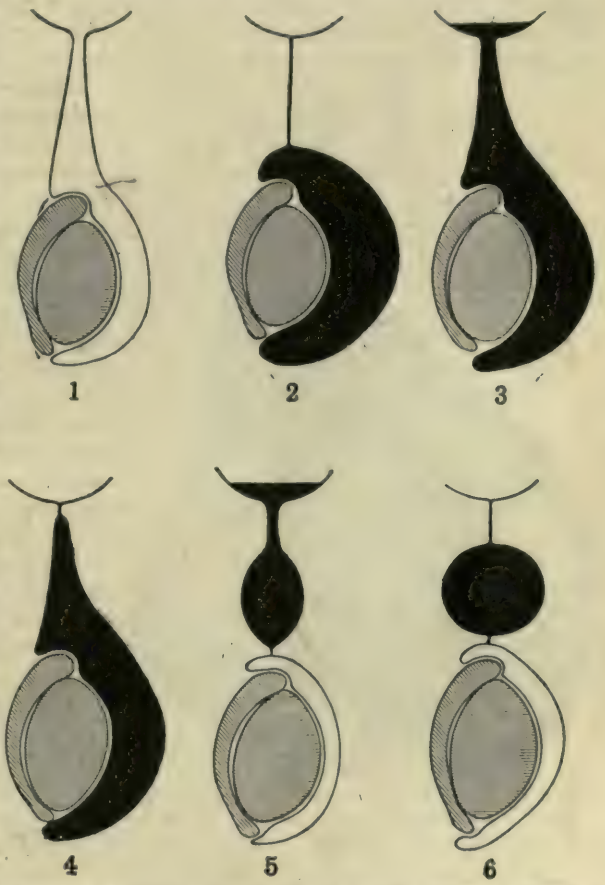



FIG. 443.—Diagram illustrating the different types of hydrocele. 1, Normal processus vaginalis. 2, Vaginal hydrocele. 3, Complete congenital hydrocele. 4, Infantile hydrocele. 5, Hydrocele of the cord. 6, Encysted hydrocele of the cord.

Such a condition may occur at any age. The sac varies in thickness from the thin peritoneal-like membrane seen in children to the thick fibrous envelope occasionally met with after repeated tappings in older patients. The fluid is usually a clear yellow or almost colourless liquid of viscid consistency, having a specific gravity of about 1025. In old patients it may be dark brown in colour, and if allowed to stand, may show on its surface a scum of glistening flakes of cholesterol. It contains enough protein to convert it into a solid mass on boiling, but although a considerable percentage of this is present as fibrinogen, it does not clot spontaneously if allowed to stand. A chylous hydrocele is one which contains a milky fluid, and in which the lymphatics of the cord have been invaded by *filaria sanguinis hominis*.

A hydrocele may be acute or chronic.

The acute cases may follow an injury to the scrotum, but are almost

always secondary to some acute inflammatory lesion in a neighbouring structure. The commoner causes are urethral epididymitis, gonococcal or pyogenic in origin, acute tuberculosis of the epididymis, and cellulitis of the scrotum.

The chronic cases may be primary—that is to say, no direct cause can be detected—or they may be secondary to syphilis, tuberculosis, or malignant disease of the testicle. In the latter two instances the fluid may be blood-stained. Operations interfering with the vessels or lymphatics of the spermatic cord, such as the radical cure of hernia or varicocele, are also occasionally followed by the formation of a hydrocele of moderate size.

Fig. 444.—Infantile hydrocele. A window has been cut in the parietal layer of the sac to show the testicle, surmounted by a stalked "hydatid of Morgagni," projecting into its lower and back portion. (St. Bartholomew's Hospital Museum.)

**Anatomical varieties of hydrocele.**—1. *Vaginal hydrocele.*—An oval or pyriform distension of the normal tunica vaginalis is found, the base of the pear being directed upwards. Occasionally a slight waist at the junction of the upper with the middle third of the swelling may be noticed, and in some cases the constriction is so marked as to give the interior of the sac a bilocular appearance. The testicle is usually embedded in the lower and back portion of the swelling, but in exceptional circumstances may be situated anteriorly (see Fig. 443, 2).

2. *Complete congenital.*—The processus vaginalis has remained patent throughout its whole length, and is in direct communication with the peritoneal cavity at the internal abdominal ring (see Fig. 443, 3).

3. *Infantile.*—Obliteration of the processus vaginalis has occurred at the internal ring only (see Figs. 443, 4, and 444). In both (2) and (3) a pear-shaped swelling is present, with its apex, as felt clinically, at the external ring and the testicle embedded in its lower and back portion.

4. *Funicular (hydrocele of the cord).*—The tunica vaginalis has developed normally and been cut off from the main processus vaginalis whilst the upper portion of the latter remains patent and communicates with the peritoneal cavity. It forms an oval swelling extending upwards from the upper pole of the testicle for a variable distance (see Fig. 443, 5).

5. *Encysted hydrocele of the cord.*—As in (4), with obliteration of the vaginal process at the internal ring. An oval or globular cyst, which has the main bulk of the tissues of the cord lying behind and on its inner side, is found above and quite distinct from the testicle (see Fig. 443, 6).

*Symptoms and signs.*—(A) *Acute hydrocele.*—This forms a painful fluid

swelling of sudden onset, which usually attains its maximum size in the course of two or three days. With proper treatment the fluid usually disappears in about ten days, but, exceptionally, is not absorbed. There may be slight reddening of the skin of the corresponding half of the scrotum and a certain amount of constitutional disturbance, but the symptoms and signs are usually masked by the more important primary lesion which underlies it.

The patient should be confined to bed with the scrotum well supported until all pain and the greater part of the fluid has disappeared. He should then be allowed up and provided with a scrotal suspender. If necessary fomentations should be applied for the relief of pain, and if the swelling is very tense it should be tapped with a fine trocar and cannula.

(B) *Chronic hydrocele.*—The ordinary variety of chronic hydrocele forms a painless oval or pyriform swelling which very slowly and steadily enlarges. It does not give rise to any symptoms, beyond inconveniencing the patient by its weight if it is allowed to attain a large size.

These swellings often feel exceedingly hard, and their fluid nature is best recognised by making the skin over them tense by grasping the back of the scrotum with the palm of the left hand, whilst the tip of the index finger of the right hand presses lightly into the anterior aspect of the swelling. In this way an impression of elasticity is obtained which is absolutely diagnostic, and the presence of even small quantities of fluid can be recognised. If tested with a small electric torch a hydrocele ought to be translucent, except in long-standing cases, where there may be considerable fibrous thickening of the sac. In this connexion it is important to remember that a scrotal hernia in a child which contains gut only is also translucent.

A hydrocele can be distinguished from a scrotal hernia by the fact that, after a little manipulation, it is usually possible to get above the swelling and isolate it from the inguinal canal. This having been done, and the finger and thumb still grasping the neck of the scrotum, it is noted that there is no impulse on coughing. The swelling is dull on percussion and, except in cases of the complete congenital type and in hydrocele of the cord, is irreducible. In both the latter varieties the patients give a characteristic history of the swelling being absent in the morning and gradually appearing during the course of the day. Their connexion with the general peritoneal cavity, however, is usually by such a minute orifice that steady pressure for at least several minutes is necessary before any appreciable diminution in size can be produced.

Hydroceles are distinguished from solid tumours of the scrotum by their characteristic feel and translucency. In cases in which a pathological lesion of the underlying testicle is suspected it is unwise to offer an opinion as to the exact condition present until all the fluid has been drawn off.

*Treatment.*—Attempts to cure a hydrocele by the withdrawal of the fluid and injection of solutions of strong irritants, such as carbolic acid or iodine, have been rightly relegated to the barbarous ages. Apart from the pain and discomfort the patient suffers, this method is uncertain in its results and may produce suppuration.

Tapping when applied to the hydroceles of infants and children, or to those cases following the radical cure of hernia or varicocele, is a useful curative measure, one withdrawal of the fluid often being sufficient. In the vaginal hydroceles of older patients, however, it must be regarded only in the light of palliative treatment. Although in a few cases, after five or six tappings at gradually lengthening intervals, the sac finally fails to refill, the percentage cured in this way is exceedingly small. Treatment by operation, on the other hand, is invariably successful.

**Tapping.**—The testicle having been identified in the lower and back part of the swelling by transillumination, the skin of the scrotum is painted with iodine and rendered tense over the anterior aspect of the hydrocele. A spot free from veins is then selected on the front and lower aspect of the latter and a fine trocar and cannula plunged in boldly in an upward and backward direction. The trocar is then withdrawn and the fluid allowed to drain slowly away. When the sac has been completely emptied the cannula is removed and the minute puncture wound sealed with a small collodion dressing.

**Operative treatment.**—1. *Excision of parietal portion of sac.*—The hydrocele having been pushed well upwards, an oblique incision is made over its upper portion through the smooth skin of the inguino-scrotal region. The wound is deepened by repeatedly drawing the knife lightly along the incision until the sac comes into view. The latter is recognised by its bluish shining appearance. The knife is now laid aside and the swelling, composed of the hydrocele and testicle, dislocated out of the wound after enucleation from the loose tissues of the scrotum by some form of blunt instrument. A strong fibrous band passing from the lower pole of the testicle to the most dependent part of the scrotum usually requires division with scissors. The sac is then opened and the parietal portion of it cut away close to its reflection on to the epididymis. Any bleeding points visible on its cut edge are underpinned and ligatured with fine silk and the testicle returned to the scrotum. It is unnecessary to attempt to destroy the endothelial covering of the visceral layer. Drainage for forty-eight hours is provided for by a small rubber tube introduced through a puncture wound in the bottom of the scrotum, and the original incision completely closed.

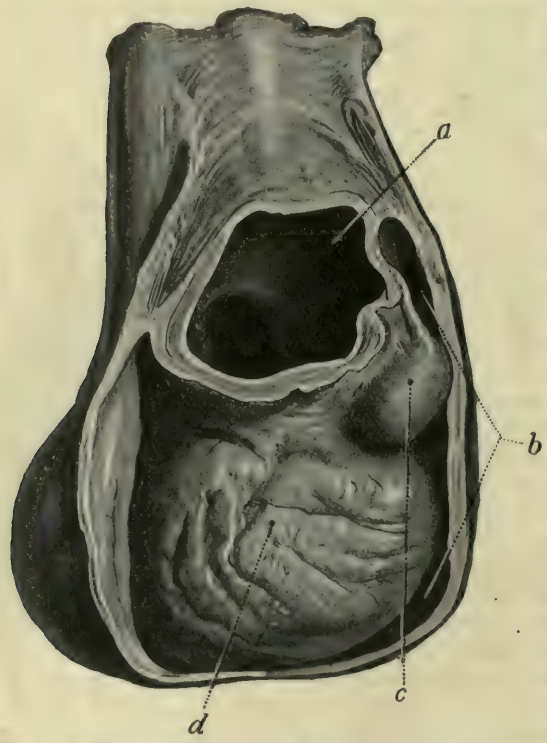



FIG. 445.—Spermatocele. *a*, Bilocular spermatocele. *b*, Cavity of normal tunica vaginalis. *c*, Globus major. *d*, Body of the testicle. (St. Bartholomew's Hospital Museum.)

2. *Inversion of sac.*—In this operation the sac is exposed as before and incised. The testicle is brought out through the opening and the tunica vaginalis turned completely inside out. The cut margins of the inverted sac are then united together with a few points of suture behind the testicle and the parietal wound closed.

This method possesses no obvious advantages over the former, and, besides

being less certain in its results, leaves an objectionable amount of tissue behind the testicle.

### Spermatocele.

A spermatocele is a cystic swelling which probably arises in those atrophic tubules of the Wolffian body which are frequently found in the tissue between the head of the epididymis and the upper pole of the body of the testicle. It contains a slightly opalescent yellowish fluid, which under the microscope shows a certain number of degenerate-looking spermatozoa.

Clinically, it rarely attains any great size and, beyond the fact of a lump being present, does not trouble the patient. It forms a globular, elastic, and translucent swelling lying upon the upper pole of the testicle, from which it can be almost completely isolated ; this fact serves to differentiate it from a vaginal hydrocele.

If necessary, it can be treated by tapping or complete excision of the sac.

### Inflammation of the Testicle.

Inflammatory lesions may affect the epididymis (*epididymitis*), the body of the testicle (*orchitis*), or both simultaneously (*epididymo-orchitis*). Simultaneous bilateral infection is practically unknown, but it frequently happens that as the testicle primarily attacked begins to subside the other one becomes affected.

*Causes.*—1. Direct extension of pathogenic organisms along the vas deferens from infections of the posterior urethra, the epididymis alone usually being infected (*urethral epididymitis*).

(*a*) Acute posterior urethritis due to the gonococcus or *bacillus coli.*

(*b*) Chronic posterior urethritis, gonococcal in origin, or secondary to stricture or enlargement of the prostate. Infection of the testicle is specially liable to occur after the passage of a urethral sound, or some operation for the relief of these conditions.

2. Hæmatogenous infection.

(*a*) This may occur in some of the acute specific fevers, notably in mumps, and appears to choose the body of the testicle rather than the epididymis. This form of orchitis is rarely seen in patients before the age of puberty, and usually appears as the parotid swelling begins to decline.

(*b*) Tuberculous disease (see p. 1134).

(*c*) Syphilis (see p. 1118).

3. Traumatism. Direct violence usually involving the whole testicle.

*Symptoms and signs.*—An attack of epididymitis begins with great pain and some swelling of the affected organ. The pain is not confined to the testicle, but is also felt as a dragging, aching sensation in the groin and back. The tail is the part most frequently involved, but the head or the whole of the epididymis may be uniformly affected, and a general tender enlargement is detected on physical examination. A certain amount of secondary hydrocele is an almost constant accompaniment, and this, together with much swelling of the epididymis, may so completely overshadow the body of the testicle that without an anæsthetic it may be impossible to identify the component parts of the gland.

Involvement of the lymphatics of the cord converts the latter into a tender, uniformly hard structure, in which it is not possible to distinguish even the vas. There is some fever and mental depression, and the patient looks and feels very ill.

The symptoms of acute orchitis are very similar to those above, except that they are usually more severe. Constitutional disturbances, such as headache and vomiting, are much more likely to occur, and the temperature, which is of the intermittent type, may reach 103° F., or even higher. Owing to the tough fibrous sheath (the *tunica albuginea*) which envelops the testicle, there is little or no swelling to be detected, but the body feels hard and is exquisitely tender. For the same reason the pain of orchitis is usually much more severe than in epididymitis alone, and destructive pressure changes are more marked.

The attack usually reaches its height in from three to five days and then gradually subsides, often, however, leaving a sensation of neuralgic pain in the testicle for many months afterwards. Suppuration is uncommon, and, when it occurs, is usually seen in those cases secondary to stricture or enlarged prostate. Sterility follows in quite an appreciable percentage of the patients and is seen even in those in whom a history of unilateral infection only can be obtained. The explanation of this probably lies in the fact that although one testicle only is affected, a bilateral infection of the vesiculæ seminales has occurred. If examined years after the original attack the epididymis may be found to contain small hard, fibrous nodules, whilst the body is small and flabby and shows diminished testicular sensation. Microscopical examination of a fresh specimen of semen at this time may reveal the complete absence of spermatozoa, or the presence of a few isolated tails or badly-staining, degenerate and non-motile specimens. The lesion responsible for this is probably not so much an actual mechanical obstruction in the tail of the epididymis, but rather a destructive change in the epithelial lining of the seminiferous tubules themselves.

*Treatment.*—Absolute rest in bed, with the testicles supported on a shelf formed by a broad piece of adhesive strapping stretched across the upper portions of the thighs, is essential. Hot hip baths or fomentations should be utilised for the relief of pain and aspirin or morphia given in addition. When the acuteness of the attack has worn off, a certain amount of pressure on the affected organ often hastens the absorption of inflammatory products and considerably diminishes the size of the swelling. This can be most readily applied by means of a short rubber bandage of about 1½ inches in breadth. The sound testicle is held out of the way and the bandage then circularly applied to the affected side of the scrotum, beginning above the maximum diameter of the swelling and working downwards.

It is most important to avoid any local treatment of the urethral condition, either by the passage of sounds, irrigation, or deep injections, until all acute mischief in the testicle has subsided.

## Syphilis of the Testicle.

In exceptional circumstances the testicle may be involved in the late stages of secondary syphilis, which in this case appears to single out the epididymis alone. The latter becomes enlarged, painful and tender, but its increase in size never attains serious proportions, and quickly subsides under appropriate antisyphilitic treatment.

In the tertiary stage the lesion is situated in the body of the testicle and is a typical gummatous change, usually occurring on one side only. Two varieties are met with :—

(*a*) The localised form, in which definite multiple nodules appear in the body of the testicle and slowly undergo caseation, producing in time some irregular nodular enlargement of the organ. This caseation may extend

through the mediastinum testis and invade the epididymis, and occasionally a distinct gummatous mass appears in the loose cellular tissues of the spermatic cord.

As the disease progresses and the firm caseous masses soften into collections of liquid gummy material, the overlying skin of the scrotum becomes adherent and reddened and eventually gives way. A deep punched-out ulcer results from the bottom of which the testicular substance is gradually extruded by cicatrisation of the surrounding tissues (*fungus testis*).

(*b*) The diffuse form, in which a very gradual smooth enlargement of the testicular body is produced by a low form of chronic inflammation which attacks the fibrous tunic and septa of the gland. Hyperæmia of the tunica vasculosa is soon followed by effusion and much new formation of young fibrous tissue along the lines of the framework of the organ. As the young fibroblasts mature into their adult form they gradually crush and strangle the glandular substance, and if the process is allowed to proceed unchecked it will produce complete atrophy of the testicle. In this form the epididymis and cord are not affected.

In both varieties a certain amount of effusion of clear fluid into the tunica vaginalis is an almost constant accompaniment.

*Symptoms and signs.*—The enlargement of the testicle, which extends over a period of months, is very slow and painless, and, except for a feeling of drag and weight in the scrotum, the patient does not appear to suffer any inconvenience from the presence of the swelling. The surface of the body of the testis may be smooth or nodular, and the organ feels uniformly and densely hard ; it is not tender and usually shows complete loss of testicular sensation. In the later stages of the localised form a patch of softening can often be detected at the spot where the skin of the scrotum is becoming adherent.

*Treatment.*—The result of the treatment of these cases, if conducted along general antisyphilitic lines, is excellent. The administration of 10-gr. doses of potassium iodide alone causes rapid diminution in the size of the swelling, and in those patients in whom the disease has not been allowed to progress to the point of complete destruction of the seminiferous tubules the normal functions and sensation of the testicle will be restored. The scrotum should be well supported with a suspender, and, if the secondary hydrocele present amounts to more than a few drachms of fluid, it should be tapped.

In cases of fungus testis a mass of foul granulations should be removed with a sharp curette, and lotio nigra applied locally in addition to the usual general antisyphilitic treatment.

## New Growths of the Testis.

*Pathology.*—Solid tumours of the testis are more frequently seen in small, imperfectly-descended organs than in those of normal development and position ; they are dangerous to life, because if not malignant in origin they are prone to become so. Rapidly-growing carcinomata or sarcomata of highly malignant nature are the growths usually met with. Both arise in the body of the testis, but spread backwards through its hilum into the epididymis, and thence extend upwards in the loose lymphatic tissues of the cord.

The sarcomata show a greater tendency to be limited by the tunica albuginea, and thus do not infiltrate the skin and fungate at such an early date. The carcinomata are usually of the soft encephaloid type, and show here and there small patches of hæmorrhage ; sarcomata are even more liable

to cystic degenerative changes, and in some cases the growth appears to the naked eye to be composed almost entirely of blood-clot. They are usually accompanied by varying quantities of clear or blood-stained effusion in the vaginal sac, and may be surrounded by an actual hæmatocele of considerable amount. They spread by the lymph and by the blood-stream, and secondary masses in the lumbar and iliac glands, the liver, and the lungs are present early in the course of the disease.

Occasionally a small growth in the testicle, not larger than a pea or a small marble, may lie dormant and remain almost stationary in size for a period

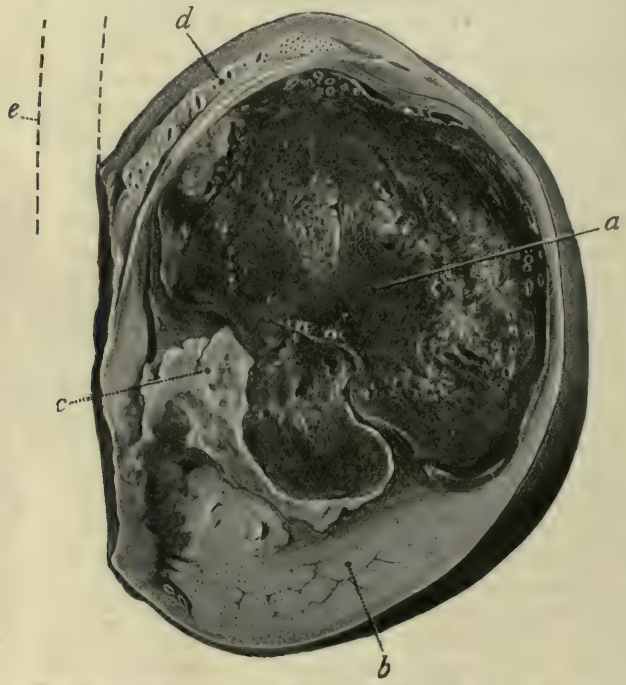



FIG. 446.—Round-celled sarcoma of testicle. *a*, Blood clot in the centre of growth. *b*, Remains of testicular substance. *c*, Necrotic portion of growth. *d*, Canal of the epididymis. *e*, Position of cord. (St. Bartholomew's Hospital Museum.)

of months, whilst large increasing masses of secondary deposit are visible in the abdomen and even in the left supraclavicular glands.

Exceptionally, the ordinary forms of spheroidal-celled carcinomata or round and mixed-celled sarcomata are seen; more often, however, the microscopical characteristics of these tumours are atypical, and it may be exceedingly difficult to classify them satisfactorily. The sarcomata frequently show a well-marked alveolar arrangement, and on section coarse fibrous septa may be seen with the naked eye dividing up the growth into loculi.

Embryonic tumours, that is to say, growths composed of fœtal tissues, are not uncommon. They arise in the mediastinum testis, and as they enlarge tend to flatten out the normal tissues of the testicular body rather than to destroy them by infiltration. On section they are seen to be composed of a conglomeration of tissues, amongst which may be noticed fibrous and

muscular tissue, a certain number of glandular-like elements and cartilage. The microscopical characters of individual tumours have been utilised for grouping them as follows :—

1. The "adenomata," which show a number of tubules or glandular spaces lined by columnar epithelium of hypoblastic origin.
2. The cystic "adenomata" (fibro-cystic disease).
3. The teratomata, composed of fibrous and muscular bundles, cartilage,

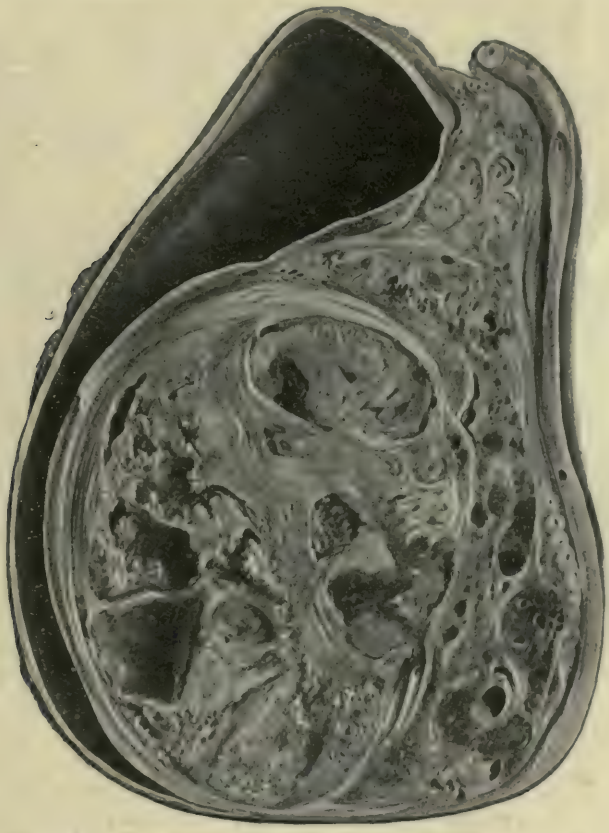


FIG. 447.—Carcinoma of the testicle. A columnar-celled carcinoma of the body of the testis with extensive infiltration of the epididymis. There is a small secondary hydrocele. (St. Bartholomew's Hospital Museum.)

bone, nerve tissue, denticles, and, occasionally, fragments of other adult organs.

These embryonic tumours usually show a slow rate of growth, and may take from three to six years, or even longer, to attain the size of a clenched fist. They often remain almost stationary and lie dormant for several years, but at any moment may begin to grow rapidly, to infect glands, and destroy life by metastasis. In other cases they appear to be malignant from the start, and if the teratomata show masses of nucleated protoplasm similar to those seen in deciduoma malignum, this is strong evidence of their highly virulent nature.

Endotheliomata have been described, but are very rare.

*Symptoms and signs.*—These growths of the testicle may occur at any age, but the favourite periods are:—Embryonic tumours from puberty up to the age of thirty years, sarcomata from twenty to forty years, and carcinomata from thirty to fifty years.

Until the skin is invaded and ulceration established, these tumours are practically painless; testicular sensation is usually lost, and the patient may complain of a dragging sensation of weight in the groins or back. In advanced cases a pyriform heavy mass with a stalk formed by the infiltrated cord is present, and the component parts of the testicle cannot be differentiated. At an earlier stage the enlarged body of the testicle usually feels smooth and elastic with the epididymis evident as a flattened band on its posterior aspect, but it may be nodular and stonily hard. If there is much secondary hydrocele, the fluid should be drawn off to enable a more accurate examination to be made.

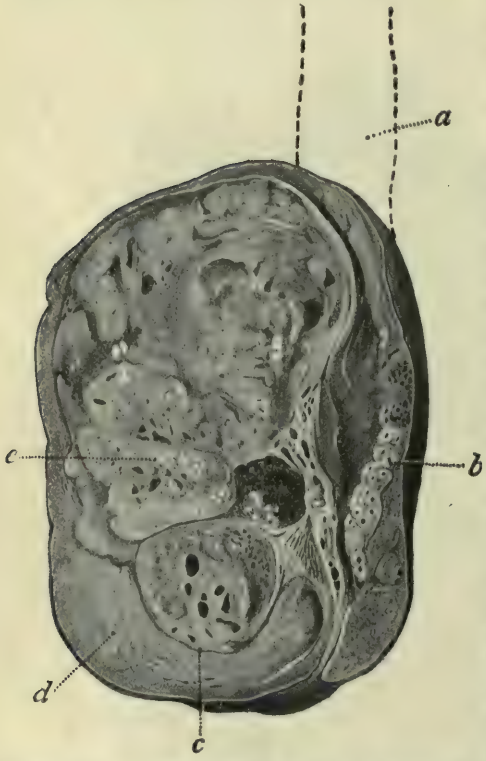



FIG. 448.—Teratoma of the testicle. The bulk of the tumour consists of sarcomatous-like tissue, which in places has a definitely alveolar structure; in addition, there are numerous islets of calcified cartilage, and spaces lined, some with stratified squamous epithelium, some with tall columnar cells. *a*, Position of cord. *b*, Canal of the epididymis. *c*, Limit of the tumour. *d*, Remains of testicular substance. *e*, Islets of calcified cartilage. The specimen was removed by operation from a man, aged thirty-five years, who had noticed a gradual enlargement of the testicle for twelve months. (St. Bartholomew's Hospital Museum.)

At first the integument of the scrotum is freely movable over the swelling, and shows large anastomosing veins. Later the skin becomes involved, and a foul, easily-bleeding mass of growth protrudes from the scrotum (*hernia testis*).

*Treatment.* — Carcinomata and sarcomata of the testicle, whether treated by operation or allowed to run their natural course, frequently kill by metastasis within eighteen months of their onset. The prognosis in the case of embryonic tumours is usually better, and if removed during their latent stage they may never recur. Some teratomata, however, from their origin are the most malignant of growths, and excel in this respect even the most virulent carcinomata.

Extensive operations, including the removal of not only the testicle and cord, but also the chain of infected lymphatics and lumbar glands, have been performed through long paraperitoneal abdominal incisions in the attempt to remove the whole of the disease.

Their efficacy is doubtful. Probably the most satisfactory procedure is to remove the testicle and cord as high as the internal abdominal ring, and to be content with this limited excision.

The operation relieves the patient of a troublesome weight, and spares him the presence of a painful and foul fungating mass in the scrotum. If in ordinary cases it does not prolong life for more than nine months or a year, it at any rate secures the patient a painless death from metastasis.

## Bacterial Infections of the Urogenital Tract.

### (A) Acute Primary Infections.

By the expression "acute primary infection" is meant a sudden invasion by pathogenic organisms of some portion or portions of an apparently healthy urinary tract, and it does not include those cases of hydro-nephrosis, stone, enlarged prostate, etc., in which an already damaged viscus becomes secondarily infected.

In a vast majority of the patients the infection is a bacillus of the coliform group, and it is to these that the following account mainly applies. In the remainder pure cultures of staphylococci, streptococci, or *B. proteus* are obtained from the urine, but their symptoms are not so dissimilar, nor their occurrence so frequent, as to warrant a special description.

In many *bacillus coli* infections of the urinary tract the symptoms for a time may be slight or even absent altogether, so that it may be impossible to be certain of the exact site of the initial invasion. Moreover, although attention is often directed to the condition by symptoms of bladder irritability, such as increased frequency or lack of control, it does not by any means follow that the original trouble was situated in that viscus. As in cases of renal tuberculosis, so here, cystoscopic examination of the ureteric orifices at the time of onset of symptoms may point clearly to disease, already of some duration, in one or both kidneys.

In women and female children the disease usually appears in the kidney, whereas in men the prostate or bladder are primarily affected. Although in the former the parenchyma of the kidney appears to suffer first, invasion of the pelvis so quickly follows, that it is impossible to separate them and the title of pyelo-nephritis is applied to the lesion. For the same reason it is more convenient to refer to an infection of the lower urinary tract in men as a cysto-prostatitis.

Many of these cases are associated with some disorder of the intestine; constipation is the commonest, but in infants under two years of age the affection is very apt to follow an acute attack of diarrhœa.

### (I.) Acute Infective Pyelo-nephritis.

*Pathology.*—In children the right kidney only is involved, or first affected, three times as often as the left; in women a still greater preponderance of the cases occurs on the right side. If the affection is a bilateral one, the onset is rarely simultaneous on the two sides, and the stress of the disease almost invariably falls upon the right kidney.

If the infection reaches the pelvis of the kidney from the colon direct across the intervening tissue, the more intimate relation of the bowel to the right kidney would suffice to explain the greater liability of that side. In some cases, however, the disease is probably due to a blood-borne infection, and the much greater frequency with which attacks of renal stasis, due to kinking of the ureter in cases of movable kidney, or to aberrant renal arteries, etc., occur in the right kidney would explain the large number of right-sided cases.

Under the title of "*pyelitis of pregnancy*" much has been written regarding the occurrence of this disease in pregnant women. These cases differ in no way from those referred to above. In them the predisposing cause to infection is probably renal stasis produced by pressure of the enlarged uterus

on the ureter, just where the latter crosses the external iliac artery to enter the pelvis. When the source of the obstruction is removed by the emptying of the uterus, either naturally or otherwise, these patients usually quickly recover. It has been suggested that the right ureter is the one almost always affected for the following reasons :—

(1) The long axis of the fœtal head usually lies in the right oblique diameter of the pelvis.

(2) The pregnant uterus undergoes a certain amount of rotation to the right around its vertical axis, and carries the right broad ligament backwards with it.

The appearances seen in the kidney depend upon the stage to which the disease has progressed before resolution occurs, and upon the virulence of the infecting organisms. In the slighter cases the kidney is enlarged and engorged with blood, and its microscopical characters are very similar to those seen in the toxic nephritis of some of the acute specific fevers. From an attack such as this the kidney recovers in a great measure, if not completely, and, except for an increased liability to a second attack, may be regarded as a normal organ. In the more severe infections suppuration occurs, and small abscesses and areas of necrosis are found scattered throughout the cortex and medulla. The kidneys, however, appear to be possessed of considerable recuperative power, and some of the atrophied and scarred organs seen in the post-mortem room have undoubtedly had their origin in a condition such as this.

In other less favourable cases, if the disease is not fatal from septicæmia during the first five or six days of the attack, the kidney gradually becomes converted into a chronic pyo-nephrosis without necessarily any great enlargement of the organ taking place.

*Symptoms and signs.*—(*a*) *The simple cases.*—The attack is ushered in with acute pain in the front and back of one or both loins, nausea, and fever, the temperature quickly rising to 103° F. and even higher. There is much rigidity and tenderness over the region of the affected kidney, which, although enlarged, is seldom palpable.

Within a few hours of the onset micturition becomes very frequent, and there is some suprapubic ache with much griping pain in the region of the bladder neck ; the symptoms of bladder irritability may actually precede those attributable to the renal condition. Hæmaturia may occur, but is unusual.

The urine for the first twenty-four hours may show no change, but soon assumes a hazy opalescent appearance, and on examination is found to be swarming with organisms and to contain a certain number of pus cells. It may be acid or neutral in reaction, and not necessarily offensive. The quantity of pus varies from a microscopical amount to quite a copious deposit in the bottom of a specimen glass. There is usually a distinct cloud of albumen on boiling.

The attack is usually at its worst during the first thirty-six hours of the disease ; the pain and fever then begin to improve, the urine gradually clears, and within five or six days of the onset the patient is to all intents and purposes quite well. The bacilluria unfortunately persists for some time, and it may need many months of careful treatment before the urine proves sterile on cultivation, and the patient can be considered safe from the risk of a recurrence of the disease.

(*b*) *The suppurative cases.*—In those cases which progress to suppuration the symptoms are very similar, and differ only in their much greater severity

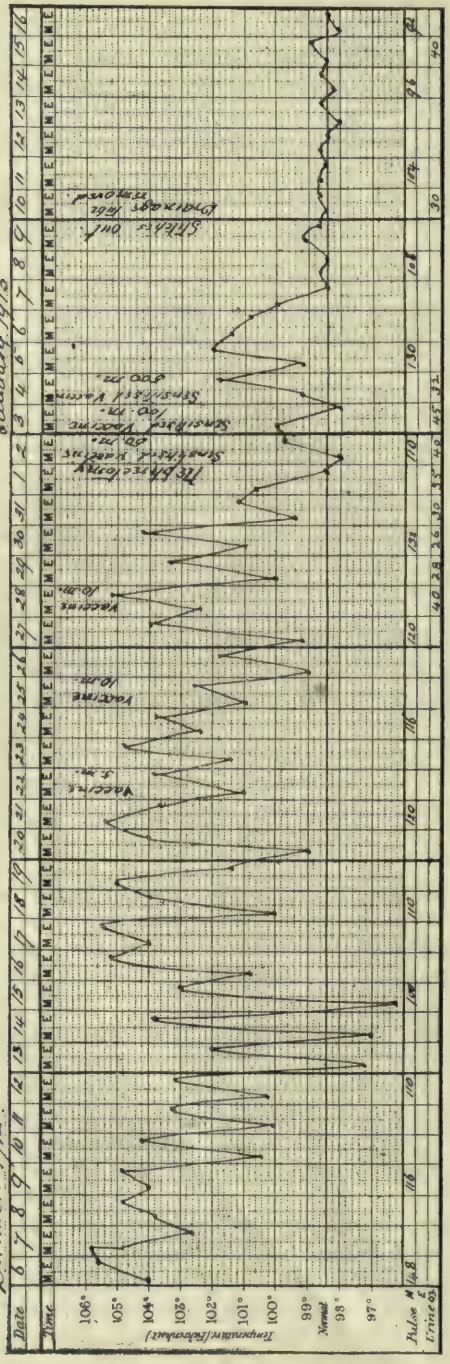


FIG. 449.—Clinical chart of a case of acute *B. coli* infection of the right kidney in a young girl, successfully treated by nephrectomy. The kidney removed is well illustrated in Plate 38.

and longer duration. After a short preliminary period of general malaise and headache the attack often begins with a well-marked rigor, which may be subsequently repeated daily, accompanied by very acute pain in the loin and back, and vomiting. There is much sweating and collapse, and the patient looks and feels extremely ill.

The temperature rushes up to 105° F.—106° F., or even higher, and, though subject to considerable oscillation during the first few weeks of the illness, rarely actually reaches the base line in its excursions.

Although there is considerable muscular rigidity over the affected loin, after the first few days it is usually possible to feel an enlarged and tender kidney. The spleen is often considerably enlarged, and, together with the affected kidney, may alter in size from day to day.

The urine is diminished in amount, and its characters are subject to considerable variation. Bursts of pyuria are accompanied by remissions in the temperature and a general abatement of symptoms, and alternate with periods in which almost clear urine is passed and a recrudescence of the pain and fever occurs. Such a course suggests strongly that there is a temporary block at the ureteral strait, damming back the pus in the renal pelvis and calyces.

The attack usually lasts from two to four weeks, during which there is great

ACUTE SUPPURATIVE PRIMARY PYELO-NEPHRITIS DUE TO BACILLUS COLI COMMUNIS.

The areas of necrosis, scattered throughout the parenchyma of the kidney, are well shown. The specimen was removed by operation from a girl *æt.* seven years, who eight years later was in perfect health. (Author's case—from the *Medical Annual*, 1914.)

distaste for food, and the patient wastes rapidly. With the disappearance of active symptoms the pus in the urine begins to diminish, the general condition to improve, and after a few weeks the patient may be regarded as on the way to convalescence. The bacilluria may persist for six months or even longer.

In the less favourable cases death may occur from septicæmia during the first week of the illness. In others relapse may follow relapse, and in bilateral cases the patient may gradually waste away from prolonged renal suppuration and eventually die of uræmia.

The symptoms of acute pyelo-nephritis may closely simulate those due to some acute general peritoneal condition such as perforation of the bowel, and may easily be mistaken for them. A correct diagnosis in a typical case of the former can usually be made by noting the following points :—

1. The muscular rigidity and tenderness, the latter being often particularly noticeable in the postrenal angle, are confined to one or both loins.
2. The extremely high temperature, which is out of proportion to the rise in the pulse rate.
3. The presence of symptoms of bladder irritability.
4. The condition of the urine.

*Treatment.*—The simple cases do not require any active surgical treatment, because the natural tendency of these patients is to get well. They should be confined to bed, placed on a milk diet, and encouraged to drink large quantities of barley water, whey, and citrated milk. Large doses of citrate of potassium reduce the acidity of the urine and tend to make the patient much more comfortable.

Pain should be relieved by hot fomentations to the abdomen and, if necessary, by suppositories of belladonna and morphia. The motions are often very offensive, and careful attention should be directed to the proper regulation of the bowels. Autogenous vaccination is sometimes followed by marked improvement in the symptoms and temperature chart, but does not appear to cut short the disease or to have any influence on the bacilluria. After the acute symptoms have subsided the patient should, if possible, be removed to a sunny, warm climate for several months and placed under the best hygienic conditions. Urotropin is useless in these cases, and of the drugs commonly employed salol given in 10 grain doses thrice daily appears to be the most efficient antiseptic.

In the suppurative cases, immediate operation is only required in exceptional circumstances. A few of the most virulent infections are fatal within the first week from septicæmia, but as a very large proportion of these cases recover without operation, and as there is no means of identifying this particular group before a general infection has occurred, nephrectomy is seldom called for at this stage, even if the disease is limited to one kidney.

In some unilateral cases, however, when after three or four weeks of continuous fever, marked wasting and profuse pyuria, no improvement is shown and the patient continues to go rapidly downhill, nephrectomy is not only justifiable but advisable (see Fig. 449). When the kidney is exposed it will be found to be riddled with small miliary abscesses (see Plate 38). In other cases, if after a prolonged illness of some months with irregular periods of pyrexia interspersed with bursts of pyuria the cystoscope shows the disease to be confined to one side, the affected kidney should be explored and a pyonephrosis drained or removed.

In bilateral cases of a similar nature something can be done by careful daily lavage of the bladder, and if renal suppuration still continues ureteral

catheters should be passed and an attempt made to improve the condition by washing out the infected pelves and calyces with weak solutions of urinary antiseptics.

### (II.) Acute Infective Cysto-prostatitis.

This disease appears to arise in the prostate, and is probably a hæmatogenous infection. Young and middle-aged men are usually affected.

*Symptoms and signs.*—The attack usually begins with extreme suddenness. The patient may be apparently in the best of health, when he is seized with an intense desire to micturate, and may find to his astonishment that his urine is stained bright red with blood. Hæmaturia, if it occurs, is not profuse and seldom lasts for more than twenty-four hours. Other and not quite such acute cases may pass from a feeling of well-being to a condition of extreme discomfort and pain within a period of three or four hours. Small quantities of scalding urine are passed at intervals of a few minutes, and there is great strangury and urgency. The urine contains much ropy muco-pus, and a certain amount of purulent urethral discharge visible at the meatus is not uncommon.

Some suprapubic tenderness can usually be elicited, and, per rectum, the prostate is prominent, exquisitely tender, and gives to the examining finger a soft boggy sensation. In an uncomplicated case the constitutional disturbance is not marked, the temperature seldom rising above 100·5° F. or 101° F. One or both testicles may be involved by direct extension along the vas deferens and add to the patient's misery; the signs are those found in the ordinary epididymo-orchitis of urethral origin.

Suppuration either in the prostate or epididymis is rare but may occur. The formation of a prostatic abscess will be shown by increased fever accompanied perhaps by a rigor, an exacerbation of all the symptoms, and increased enlargement and bogginess of the prostate as felt per rectum.

*Treatment.*—The treatment is essentially the same as for any other form of acute cystitis (see p. 1070), but here, as in the kidney, *bacillus coli* is an exceedingly difficult organism to get rid of. If suppuration occurs in the prostate the abscess should be opened as soon as possible before it has passed beyond the limits of the prostatic sheath, and either spread into the loose cellular tissue of the pelvis or burst into the rectum.

A metal sound having been passed into the bladder, the patient is placed in the lithotomy position, and a slightly-curved transverse incision with its convexity forwards is made in the perineum. The cut is deepened until the base of the triangular ligament is exposed. The anterior edge of the incision containing the membranous urethra is then retracted strongly forwards, and with a finger of the left hand passed into the rectum as a guide, a director is pushed onwards into the prostate until pus is reached. A pair of sinus forceps is passed along the director, and, free drainage having been established, a rubber tube is inserted into the cavity.

## (B) Chronic Infections.

### Tuberculous Disease.

This description does not include the miliary tuberculosis which occurs as part of a generalised infection; also, the word "primary," as used in this section, refers to the particular portion of the genito-urinary tract first affected, and is not meant to denote that the disease has not been preceded by a tuber-

culous lesion in some other part of the body. Post-mortem examination shows that in roughly 60 per cent. of the cases dying with genito-urinary tuberculosis there is evidence of a similar lesion, either active or obsolete, in the lungs, lymphatic glands, or elsewhere.

The disease is in all cases the result of a blood-borne infection. It is primary either in the kidney or in some portion, usually the prostate or epididymis of the lower tract. The former site is the commoner. Primary deposits of tubercle have been described as occurring in the bladder, usually in its postero-superior wall, but these cases must be regarded as very exceptional.

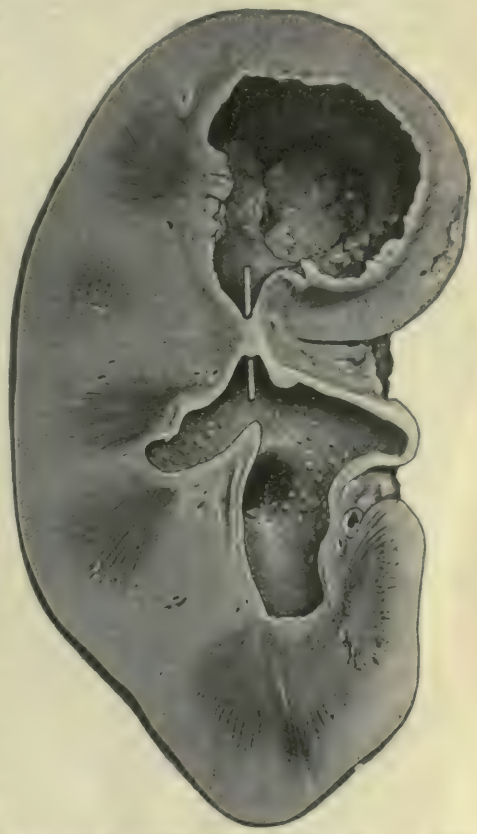


FIG. 450.—Tuberculosis of the kidney. A pus-containing cavity in the upper pole of the kidney is seen communicating with the renal pelvis, the mucous membrane of which has become infected and is studded with numerous small miliary tubercles. (Cancer Hospital Museum. Mr. Swan's case.)

### (A) Renal Tuberculosis.

*Pathology.* — Renal tuberculosis is in the first instance a unilateral infection, and shows little tendency to affect the opposite kidney. Post-mortem examination of patients dying with renal tuberculosis, *i.e.*, presumably advanced cases, shows that in two-thirds of these the disease is still confined to one kidney. The affected organ may eventually become converted into an obsolete caseous mass encysted, in a dense fibro-lipomatous envelope, but, short of complete destruction of the kidney, the disease shows little or no tendency towards spontaneous healing.

One pole of the kidney, usually the upper, is first attacked, tubercle bacilli being deposited either towards the centre or in the apex of a pyramid. The latter is slowly converted into a wedge-shaped caseous mass with lines of small miliary tubercles extending outwards towards the surface of the kidney. The organ begins to show some enlargement and lobulation as other pyramids are affected, and reddened patches on its surface indicate the position of the caseous masses in its interior.

Liquefaction of the latter soon takes place, and the pus, finding its way into the renal pelvis, is discharged down the ureter.

The mucous lining of the pelvis and ureter becomes converted into a granular friable membrane, and there is usually much inflammatory thickening of the tissues surrounding the somewhat dilated ureter. Finally the loose tissue of the fatty capsule of the kidney becomes infected and a perinephric abscess

results. The bladder in its turn becomes involved, the first change occurring in and around the ureteric opening of the affected side. The pathological appearances of a ureteric opening, as noted with the cystoscope, are exceedingly valuable in localising the disease, and three stages may be identified.

1. The lips of the opening are raised and pouting, and have a pink, œdematous, semitranslucent appearance.

2. The opening gapes and its lips have an irregular, ragged appearance from superficial ulceration. The surrounding bladder wall is of a dull-red colour, and may show small miliary tubercles on it. At this stage slight parallel ridges of the trigonal mucous membrane in the immediate vicinity may be evident, and the appearances seen suggest that the ureteric opening is being pulled in an upward and outward direction by the periureteritis which is always present.

Fig. 451.—Tuberculosis of the kidney. Four of the pyramids are occupied by softened caseous masses which are in direct communication with the cavity of the renal pelvis. In the lower pole of the kidney small miliary tubercles can be seen extending outwards towards the periphery of the cortex. (St. Bartholomew's Hospital Museum.)

3. The former position of the ureteric opening is represented by a deep gaping pit with ragged ulcerated walls, at the bottom of which the ureter opens, but is not usually visible.

Tuberculous disease is first evident in the bladder as slightly-raised, irregular red patches with small flakes of muco-pus adherent to their surfaces. Later, dotted about on one of these patches, pearly or yellowish-grey tubercles can be seen. These in the course of time soften, and become shallow ulcers with greyish-black sloughy bases and bright-red areolæ around their clean-cut edges. The ulcers gradually run together, and eventually the greater part of the mucous lining is destroyed. It is replaced by a friable granular membrane, showing here and there semi-pedunculated masses of proliferating granulations, and a certain amount of phosphatic *débris*.

The disease gradually spreads by direct extension to the prostate, vesicles, and testicles.

*Symptoms and signs.*—Renal tuberculosis can be considered best by separating the cases into three stages depending upon the extent and duration of the disease and considering each stage separately.

*Stage* 1.—A caseous mass in one pole of the kidney, not communicating with the pelvis.

The patient is anæmic, and confesses to a feeling of weakness and lack of

energy of some six to twelve months' duration. There may be some increased frequency of micturition, perhaps due to the irritating character of the urine excreted, as at this time the lips of the corresponding ureteric opening show some œdema.

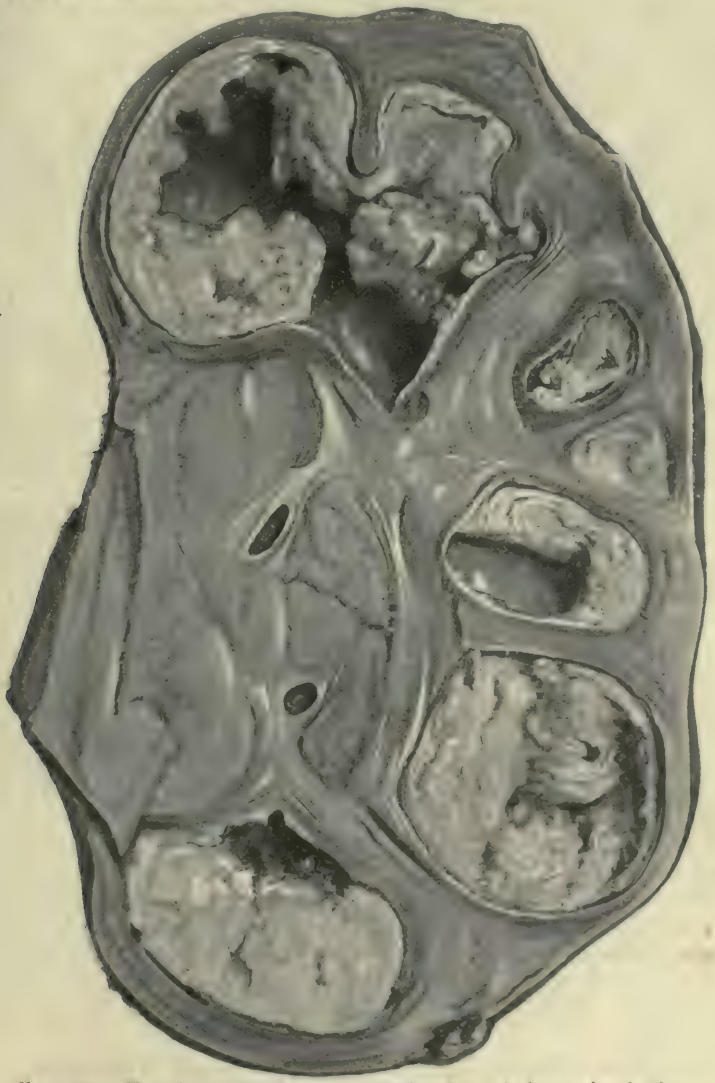


Fig. 452.—Chronic tuberculous pyo-nephrosis. A large hard fibro-lipomatous mass is seen occupying the renal sinus. (St. Bartholomew's Hospital Museum.)

Nothing can be felt in the abdomen and the urine is natural, except that, occasionally, a trace of albumen is present.

*Stage* 2.—One or more pus-containing cavities in the kidney in direct communication with the renal pelvis.

Apart from the occasional presence of a slight postrenal ache, the symptoms are entirely referable to the bladder. The frequency is increased by night and by day, and there is pain referred to the frænum or root of the penis as

micturition is completed. Occasionally symptoms are entirely absent until an acute clinical onset is caused by the sudden discharge of a considerable amount of pus down the ureter. This is accompanied by abdominal pain and a burst of increased frequency and strangury, which begin to subside in twenty-four to forty-eight hours, and may completely disappear for the time being. Hæmaturia may occur, but is unusual. It may take the form of a slight straining of the urine of two or three days' duration, or when a fair-sized vessel is eroded by ulceration, of a profuse hæmorrhage of quite alarming proportions. The latter is accompanied by abdominal pain, and the bladder may become so distended with clot that it has to be emptied with an evacuator. Abdominal examination reveals nothing beyond perhaps slight tenderness and muscular rigidity in the loin of the affected side. The most important and often sole physical sign at this stage is a thickened rod-like ureter felt from the vagina or rectum on bimanual examination.

Cystoscopy reveals a gaping, ulcerated, and "pulled-out" ureteric opening.

The urine contains pus, some albumen, and, in the absence of a secondary infection, is acid in reaction. There is as a rule no fever.

*Stage* 3.—A perinephric abscess.

Here a secondary infection is often present, and a tender and somewhat ill-defined lumbar swelling is accompanied by a rise in temperature amounting to 1 or 2 degrees in the evening.

There may be some reddening and œdema of the skin on the posterior aspect of the loin.

Every effort should be made to arrive at a correct diagnosis as early as possible in stage 2. An acid pyuria, occurring in a young adult in whom there is no evidence of any chronic venereal infection of the posterior urethra and prostate, is almost certainly due to a pure infection of the tubercle bacillus or *bacillus coli*, or to a mixture of both. Should the urine prove sterile on cultivation, this is very suggestive, although not absolutely diagnostic, of tuberculous disease.

The diagnosis is completed by the finding of the tubercle bacillus in the urine, although repeated examinations may be necessary before this is accomplished. The deposit from the whole of a twenty-four hours' specimen should be utilised for this purpose, and should be treated by the antiformin method before staining.

In the absence of proof of this kind recourse must be had to animal experiment. Exceptionally, it may be possible to obtain positive evidence from a guinea-pig injected with a tuberculous urine in three weeks, but a period of from six weeks to six months may be necessary, and in the presence of suspicious clinical evidence surgical treatment should not be delayed for this length of time.

The existence of a tuberculous lesion in some portion of the genito-urinary tract having been proved by an examination of the urine, the presence of disease in the prostate and testicles is first excluded as far as possible by careful examination.

Cystoscopy then locates the disease in one kidney, and the fact that the patient possesses a second organ which is healthy and efficient is determined by ureteric catheterisation.

*Treatment.*—The treatment of unilateral renal tuberculosis, without marked infection of the lower tract or elsewhere, is by immediate nephrectomy. This should be performed by the lumbar route, and every attempt made to remove the kidney without opening it and so avoid infection of the loose fatty tissue

of the loin. If the ureter shows much dilatation and periureteritis, it is advisable to remove it at the same time; this should be done by a separate extraperitoneal inguinal incision.

Infection of the bladder for a limited extent around the ureteric opening, or the presence of a small nodule in the prostate or epididymis, is no contra-indication to operation.

Apart from the great improvement in the general condition, and the relief of distressing bladder symptoms, which the patient derives from the removal of the primary suppurating focus, it is surprising how small deposits in the lower tract will clear up and disappear under improved hygienic conditions. There is little or no tendency for a tuberculous renal lesion to heal spontaneously, and although, even without operation, these patients may live for a number of years, the disease is ultimately fatal from an ascending secondary infection or from general dissemination.

For those cases which are unsuitable for nephrectomy little can be done beyond rendering the patient more comfortable by the method suggested for tuberculosis of the bladder. A perinephric abscess should be evacuated by a lumbar incision and an attempt made to secure primary union of the parietal wound.

Unfortunately a large proportion of these cases have already become infected with *bacillus coli*, and a permanent discharging sinus in the loin will almost inevitably result.

## (B) Tuberculosis of the Lower Genito-urinary Tract.

Tuberculous disease may be primary in the prostate or the epididymis. Until recently it was generally believed that in the great majority of these cases the disease began in one epididymis, and thence spread upwards by direct extension along the vas to the seminal vesicles and prostate. In view of a certain amount of animal experiment, however, and after careful reconsideration of many of the clinical findings of the disease, this belief is being gradually abandoned.

The following facts suggest that the prostate is the primary site of invasion in most of the patients, and that the involvement of one, and later of the second testicle, is due to direct extension downwards of the tuberculous process along the vasa :—

1. The epididymis and not the body of the testicle is always involved first—that is to say, unlike the behaviour of the tubercle bacillus elsewhere, the conducting and not the secreting portion of the gland is attacked. That the body is no unsuitable medium is evident from the readiness with which it becomes infected by extension of the tuberculous focus in the epididymis through the mediastinum testis. Moreover, as the vessels enter the two portions of the testicle in two distinct and isolated bundles, if the tubercle bacillus invaded the gland by way of the blood-stream and not by extension from the prostate, it is difficult to understand why it should single out the epididymis in practically every case.

2. Thickening of the vas of the affected side can usually be detected on the first occasion a patient suffering with tuberculous epididymis comes under observation.

3. Tuberculosis of the prostate in its early stages is not recognised because it causes no symptoms, and it is only when the bladder becomes involved, or hard nodules project through the dense prostatic sheath and are palpable per rectum, that the disease is likely to be identified. On the other hand,

in well-marked testicular cases it is unusual not to be able to find clinical evidence of prostatic involvement, *i.e.*, disease of some considerable duration.

4. Whether the testicle first affected is removed by operation or not, the disease almost invariably shows itself later in the organ of the opposite side.

**Tuberculosis of the prostate gland.**—Tuberculosis of the prostate does not become evident until the prostatic urethra and neck of the bladder are involved, when the symptoms are those of vesical tuberculosis, viz., increased frequency, urgency, and painful micturition, accompanied by an acid pyuria. Hæmaturia may occur, but does not amount to more than slight staining from time to time of the last few drops of urine passed.

A slightly-enlarged and nodular prostate may be detected per rectum. The nodules may show patches of softening, and are more circumscribed and prominent than those found in malignant disease of that organ. Later, a uniform, rounded and elastic swelling is felt if suppuration takes place.

In some patients the disease remains almost stationary for several years, but in the majority a slowly progressive change occurs in the bladder, and the latter contracts down until its capacity only amounts to 1 or 2 oz. Micturition occurs every few minutes, accompanied by much spasmodic pain in the region of the bladder neck, and the patient is gradually worn out by pain and lack of sleep. The kidneys show a certain amount of pelvic dilatation and interstitial fibrous change as the result of obstruction at the intravesical portion of the ureter, and readily fall victims to an ascending secondary infection.

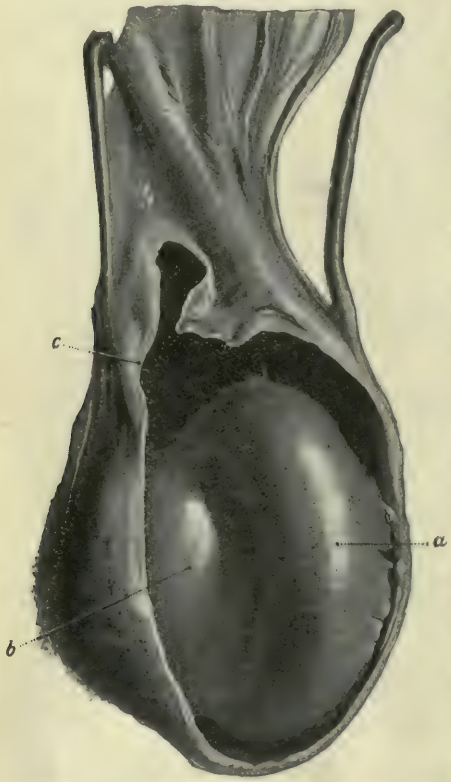



Fig. 453.—Tuberculosis of the testicle. The specimen shows marked general enlargement of the epididymis with a small secondary vaginal hydrocele. *a*, Enlarged epididymis. *b*, Body of the testicle. *c*, Tunica vaginalis. (St. Bartholomew's Hospital Museum.)

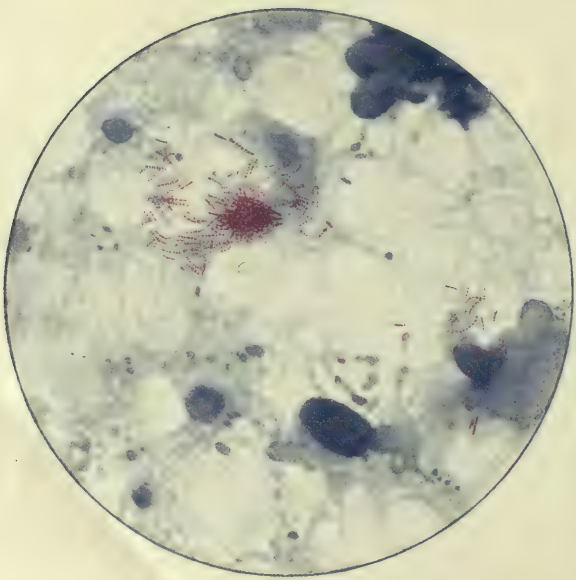
**Tuberculosis of the testicle.**—The onset of tuberculous disease of the testicle may be acute or chronic, the latter being by far the commoner.

(*a*) *Chronic tuberculosis.*—A slight aching sensation may be felt in the affected testicle, but usually the first sign is a small caseous nodule in the head or tail of the epididymis, discovered accidentally by the patient, or noted by the surgeon during the course of a routine examination. The nodule feels densely hard, and is not tender. There is thickening of the vas, but the other constituents of the cord remain natural and can be rolled individually between the fingers.

The nodule, after remaining quiescent for some time, may gradually shrink,

(*a*) Tuberculous Disease of the Testicle.

The head and tail of the epididymis are occupied by caseous masses, the lower of which has invaded the body of the testicle. The vas deferens also shows marked caseous infiltration. (St. Bartholomew's Hospital Museum.)



(*b*) Tubercle Bacilli in Urine.

Film of pus treated by the anti-formin method and stained to show a clump of acid-fast bacilli.

but usually more nodules appear, and, after a varying period of months, soften. The overlying skin becomes reddened and adherent, and the pus, gradually finding its way to the surface, is discharged, leaving a sinus. The latter may close after discharging a thin purulent fluid for some months, but occasionally a mass of easily-bleeding, foul, tuberculous granulations is slowly extruded from the scrotum (*fungus testis*).

(*b*) *Acute tuberculosis.*—The onset is sudden, and closely resembles the ordinary form of gonorrhœal epididymo-orchitis. There is much pain and reddening of the skin of the scrotum, and within forty-eight hours considerable swelling results from the development of a secondary hydrocele.

The epididymis is exquisitely tender, and shows a general smooth oval enlargement. There is also some thickening of the vas deferens.

Unlike the gonococcal cases, the major portion of the swelling does not subside in a week, although the pain and tenderness show much improvement by that time. The epididymis usually suppurates, and an abscess appears within two or three weeks of the onset.

*Treatment.*—Little active surgical treatment is possible in cases of tuberculosis of the lower genito-urinary tract. Removal of one testicle or epididymis for a caseous nodule cannot be regarded as a satisfactory procedure, because within a short time the disease becomes evident in the other testicle or prostate. Moreover, the cases in which the disease is discovered whilst still confined strictly to the prostate, and suitable therefore for perineal removal of the gland, are very exceptional.

Castration should be reserved for the acute suppurating cases, or for those chronic cases in which a persistent sinus or fungus testis has resulted and it is desirable to rid the patient of a serious inconvenience.

For most of the cases palliative treatment is more satisfactory, and the patient should be put under the best possible conditions of diet and climate. When the bladder is implicated, all pungent substances in the food and alcohol should be avoided and the patient rendered more comfortable by the administration of sandal-wood oil or "gonosan," given in 5 minim doses three or four times a day.

In some patients marked improvement has followed the injection of small doses of tuberculin, given at intervals of ten days. The initial dose should be $\frac{1}{100,000}$ m.g. of tuberculin T.R. and the amount gradually increased up to, but not exceeding, $\frac{1}{20,000}$ m.g. Whilst under treatment, careful records should be kept of the patient's progress by charting the weight, frequency of micturition, pain, and character of the urine; if no improvement is evident in two months the injections should be discontinued.

Except for one cystoscopic examination, if necessary for diagnosis, the passage of instruments should be sedulously avoided, and the practice of daily lavage of the bladder in tuberculous cases cannot be too strongly condemned, as, however aseptically this is carried out, secondary infection is bound to occur. This accident is shown by increased pain and frequency, a rise in temperature, and an alkaline reaction of the urine.

In the final stages, when a secondary infection is present and suppositories of morphia and belladonna no longer control the pain, a suprapubic drainage operation will often afford the patient great relief.

# Section XXVII.

## SOME DISEASES OF THE FEMALE GENITAL SYSTEM.

### Carcinoma of the Vulva.

Carcinoma of the vulva is a disease of later life, and is most common between the ages of fifty and seventy. It is seen more often amongst women who have borne children than amongst those who have not, and is sometimes preceded by leucoplakia—a condition characterised by the presence of irregular plaques on the skin of the labia, at first opaline and transparent, but later silvery and opaque.

Fig. 454.—Squamous-celled carcinoma of the labium majus.

**Morbid anatomy.** — In the earlier stages the cancer forms a small warty growth, situated most often on the inner surface of the labium majus (Fig. 454), or on the clitoris. The surface of the growth ulcerates, and accordingly as tissue formation or disintegration proceeds more rapidly we find eventually a tumour, a diffuse infiltration or a deep crater-like ulcer. The cancer penetrates into the surrounding tissue and becomes fixed to the pubic and ischial rami. Occasionally a symmetrically placed growth is found on the opposite labium, possibly the result of auto-inoculation by cancer cells from the primary growth.

Excepting the rare cases of carcinoma of the gland of Bartholin, the growths are squamous-celled. Proliferations of the surface epithelium penetrate the connective tissues, and in microscopic sections appear as columns and islands of squamous cells surrounded by inflammatory exudations. The cells of the growth are irregular in size and shape; the nuclei are large and often contain mitotic figures; cell-nests are common, which when keratinised form the so-called carcinomatous pearls.

The cancer spreads by local extension, by the lymphatics, and by the blood stream. The inguinal and femoral groups of lymphatic glands are first affected, but in advanced cases the iliac, lumbar and pre-sacral glands

may also be involved. Visceral metastases, the result of carcinomatous emboli, have been found in the liver, kidney, heart and lungs.

**Symptoms.**—Pruritus vulvæ is often the first symptom, and may precede the appearance of the growth by some months; it is due to irritation of the nerve endings of the ilio-inguinal and cutaneous branches of the pudic nerves, and is paroxysmal. When ulceration commences a discharge is present, sometimes purulent, sometimes thin, watery and blood-stained. Pain is a late symptom, and when present is felt in the vagina, in the lower abdomen, and down the thighs. Painful and difficult micturition may result from involvement of the urethra, and in the last stages anæmia and cachexia are present.

**Physical signs.**—When ulceration has commenced the disease spreads rapidly, involving the labia and skin of the surrounding region, but only rarely the vaginal walls. The growth is friable, and bleeds readily on touch. Downgrowths penetrate deeply, and are felt as hard cords. Finally the tumour becomes fixed to the bones of the pubic arch.

**Diagnosis.**—Papillomata of the skin and adenomata of the sebaceous or sweat glands may be mistaken for early carcinoma, and in case of doubt should be removed and submitted to microscopical examination. Condylomata acuminata are distinguished by the fact that they show little tendency to bleed on touch, do not infiltrate, and when scraped away leave a raw, bleeding surface without induration.

A primary syphilitic sore forms either a papule or an ulcer with thickened edges and sloughy base. A diagnosis can be made even before the appearance of secondary symptoms by scraping and examining for spirochætes the serum exuded. In tubercle and in esthiomène, ulceration and repair are often seen in progress in different parts of the lesion; there is little or no bleeding on touch and little tissue-infiltration. In any doubtful ulcer or growth of the vulva, a portion of tissue should be removed for microscopical examination.

**Treatment.**—The only hope of cure lies in a radical operation. The vulva should be removed freely by incisions commencing at the mons veneris above and terminating at the posterior commissure below, and should include an area of skin wide of the growth. The oval mass thus marked out is wrapped in gauze, seized with a volsellum, and drawn away from the body. The labia and underlying tissues down to the deep fascia are removed; bleeding vessels are then secured and the wound closed by catgut sutures. The inguinal and femoral glands of both sides should be removed, preferably by a T-shaped incision over the inguinal canal and along the course of the femoral vessels.

## Uterine Fibromyomata.

Fibromyomata are innocent tumours composed of unstriped muscle and fibrous tissue in varying proportions. They arise most commonly in the wall of the uterus and possess a capsule formed from the surrounding tissues compressed and displaced by the growth of the tumour.

**Etiology.**—*Frequency.*—These tumours are very common, and are found in 15 per cent. of women above the age of thirty-five. In the majority of cases they never attain a size sufficient to cause symptoms or require treatment.

*Age.*—Fibromyomata develop during the child-bearing period of life; they are extremely rare before puberty and usually cease to grow after the menopause. Most of the patients who seek advice because of symptoms are between the ages of thirty and fifty.

*Child-bearing.*—Fibroids occur in both the married and the unmarried, in the barren and the fertile, but are relatively more common in women who have not borne children.

**Morbid anatomy.**—The tumours may be single or multiple. They are found most often in the body of the uterus, less often in the cervix, and occasionally in the round and ovarian ligaments; very rarely they arise in the thin sheet of unstriped muscle which lies between the two layers of the broad ligament. In the earlier stages of their development they are situated in the muscular layer of the uterine wall and may remain surrounded by a capsule of uterine muscle (interstitial fibroids), or as they grow they may project from the peritoneal surface (subperitoneal fibroids) or into the cavity of the uterus (submucous fibroids). A submucous fibroid may become extruded from the uterine wall, remaining attached by a thin pedicle only (fibroid polypus), or a subperitoneal fibroid may acquire a secondary vascular supply through adhesions to omentum or intestine and become completely detached from the uterus (parasitic fibroid). The larger tumours are composed partly of muscle and partly of fibrous tissue; but, since the smallest tumours consist almost entirely of muscle, it is possible that the fibrous tissue found in the larger growths may be formed from degenerate muscle. They grow slowly and may exist for many years without causing symptoms. A sudden increase in their size may result from degeneration or from sarcomatous change. On section fibroids have a curious whorled appearance from the concentric arrangement of the bands of muscle and strands of fibrous tissue of which they are composed; a tumour may be built up of many such whorls separated from one another by trabeculæ of fibrous tissue. As a rule their blood supply is scanty, but in one variety (telangiectatic fibroids) large numbers of thin-walled vessels are seen in every part of the tumour.

*Cervical fibroids* may arise in the tissue of either the supravaginal or vaginal portions of the cervix. In the former situation they strip up the peritoneum and lie in the parametric cellular tissue, often displacing the bladder; in the latter they form tumours projecting into the vagina.

*Fibromyoadenomata.*—In these tumours islands of uterine mucosa are found embedded in the muscle and fibrous tissue; the mucosa, consisting of both glands and interglandular stroma, closely resembles the normal endometrium and undergoes analogous changes during menstruation and pregnancy. As a rule these tumours possess no definite capsule, but fuse imperceptibly with the adjacent uterine wall. They seldom attain a large size, and are found most commonly in the neighbourhood of the uterine cornua.

*Origin of fibroids.*—It is held by some pathologists that since the tissues of very small fibromata are often arranged concentrically around a central vessel they develop from embryonic cells situated in the adventitia of the smaller arterioles, that the embryonic cells are transformed into unstriped muscle fibres, and that the fibres situated more distally from the vessel gradually degenerate into fibrous tissue. It is more probable, however, that the proliferating tissues are part of the uterine parenchyma and not of the blood-vessel. In the smaller tumours the fibres do not possess the characteristic whorled arrangement and no capsule is present, but as the growth enlarges the surrounding tissues are pushed aside and compressed to form a capsule.

**Symptoms.**—The symptoms caused by fibromyomata depend upon their size, their situation, and upon pathological changes occurring in them.

*Hæmorrhage.*—Tumours which encroach upon the uterine cavity cause

bleeding. The history is usually one of gradually increasing loss at the menstrual periods—*menorrhagia*. The periods are increased in duration, the intervals between them are diminished, an increased quantity of blood is lost on each day, and not uncommonly clots are passed. The hæmorrhage is due chiefly to the enlarged size of the uterine cavity, but is due in part to hypertrophy of the endometrium and in part to degenerative changes in the uterine muscle, whereby its contractility is lessened. As the fibroid grows and projects further into the uterine cavity the amount of hæmorrhage increases and the patient becomes anæmic, sometimes blanched, and suffers from breathlessness and cardiac palpitation. By contractions of the muscular wall of the uterus the fibroid may be gradually expelled into the cavity and remain attached by a pedicle only; in such cases the bleeding often becomes almost continuous. As a result of the profound anæmia the patient's general health suffers severely and changes of degeneration are often found in the cardiac muscle.

*Dysmenorrhœa.*—A fibroid in the uterine wall acts like a foreign body, and the regular peristaltic contractions which accompany normal menstruation are rendered irregular and painful; the uterus makes attempts to expel the fibroid, hence the contractions are powerful and sometimes become veritable labour pains. Generally speaking the more a fibroid approaches the endometrium the severer the dysmenorrhœa becomes.

*Pressure symptoms.*—Large tumours occupying the abdominal cavity may interfere with the movements of the diaphragm and cause dyspnœa or may press upon the gastro-intestinal tract and give rise to indigestion, but the severest pressure symptoms are caused by tumours situated partially or entirely in the pelvis. The gravest symptoms are connected with the urinary organs; the neck of the bladder and the urethra may be so compressed against the posterior aspect of the os pubis as to cause retention of urine; the bladder then becomes distended, the ureters and the pelves of the kidneys are dilated, and hydro-nephrosis results; its onset gives rise to severe pain in the back and sometimes to albuminuria. From the constant passage of the catheter infection is a common event and may lead to suppuration in the kidneys and death from uræmia. A fibroid situated low down in the posterior wall of the uterus may compress the rectum against the anterior aspect of the sacrum and cause obstinate constipation or even chronic intestinal obstruction. Pressure upon the cords of the lumbo-sacral plexus causes severe pain or difficulty in walking, and pressure upon the great veins may lead to œdema of the legs.

**Pathological changes in fibromyomata.**—Fibroids are liable to undergo pathological changes which not infrequently cause severe symptoms and sometimes prove fatal.

*Red degeneration* (*Necrobiosis*).—This condition is found most commonly in interstitial fibroids of moderate size; it may affect the whole tumour or may be limited to one portion of it. The tissues are softened and stained uniformly of a bright red colour which deepens on exposure to the air; they emit a curious odour similar to that of decaying fish. The blood-vessels, often large and conspicuous, are filled with thrombi, and around the thrombosed vessels are deposits of fat crystals. The red colour is due to staining of the tissues with hæmoglobin and its derivatives. It is probable that thrombosis is the primary event, that the deposit of fat crystals is due to changes in the circulation resulting from the thrombosis, and that diffusion of hæmoglobin is caused by the hæmolytic action of lipoids so deposited. By some pathologists red degeneration is regarded as the result of bacterial

infection; in many cases, however, cultures prove sterile, and in the cases where organisms have been grown the infection is probably a secondary phenomenon.

Red degeneration occurs most often during pregnancy or the puerperium, but it is by no means limited to these conditions; it is often attended by acute symptoms such as severe abdominal pain and tenderness, a rise of temperature, increased pulse-rate, and vomiting.

*Necrosis* is often secondary to red degeneration; the tissues in the interior of the fibroid die and undergo liquefaction, so that a cyst-like cavity is formed with ragged, irregular walls of fibromyomatous tissue and fluid contents consisting of tissue *débris* and cholesterin crystals.

*Calcareous degeneration.*—In tumours of long standing the tissues often undergo a process of atrophy and sclerosis; such senile changes may be

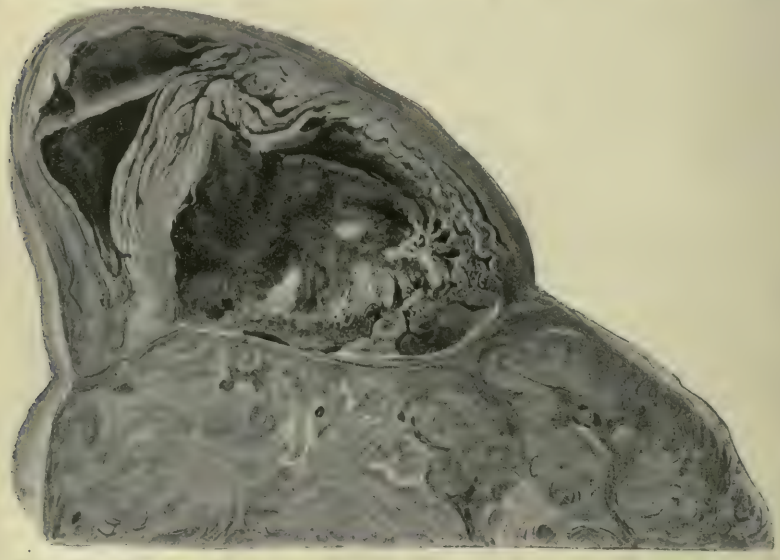


FIG. 455.—Portion of uterine fibromyoma showing necrosis. (St. Bartholomew's Hospital Museum.)

associated with the deposit of calcareous salts so that the whole tumour becomes calcified. Calcified fibromyomata may exist for years without causing symptoms, but not infrequently contract adhesions with the bowels and other viscera.

*Cystic degeneration* is usually associated with circulatory disturbances; the tissues undergo first hyaline change, then liquefaction, and finally a thin-walled cyst replaces the solid tumour. The cavity of the cyst is often traversed by bands of tissue dividing it more or less completely into loculi filled with fluid contents. Clinically the onset of cystic degeneration is characterised by softening of the tumour and an increase in its size.

*Infection* occurs most often in fibromyomata in process of expulsion. The partially-dilated cervix forms a ring of constriction interfering seriously with the circulation in the part of the tumour projecting into the vagina; the vitality of the tissues is impaired and microbic infection follows. The surface of the tumour is covered by a green or yellow slough which disintegrates and gives rise to an offensive purulent discharge. The infection

may spread through lymphatic or vascular channels and a fatal pyæmia or septicæmia ensue. Subperitoneal fibroids are occasionally infected through the bowel wall; in such cases coils of intestine become fixed by adhesions to the peritoneal covering of the tumour and may cause great difficulties at operation. Many of the gravest infections follow labours, when during the process of delivery the fibroid has been injured; the whole tumour may be converted into a sloughing mass riddled with abscesses and undergo partial extrusion into the vagina.

**Fibroids and malignant disease.**—The presence of a fibroid in the uterus offers no protection from the development of cancer; the association of fibroids with carcinoma of the cervix or body is not uncommon, and in the latter event the tissues of the fibroid are themselves invaded by the malignant cells. The simultaneous growth of sarcoma and fibroids of the uterus is rarer, but is met with occasionally: the tissues of a fibromyoma sometimes undergo a malignant change and the tumour is converted into a sarcoma.

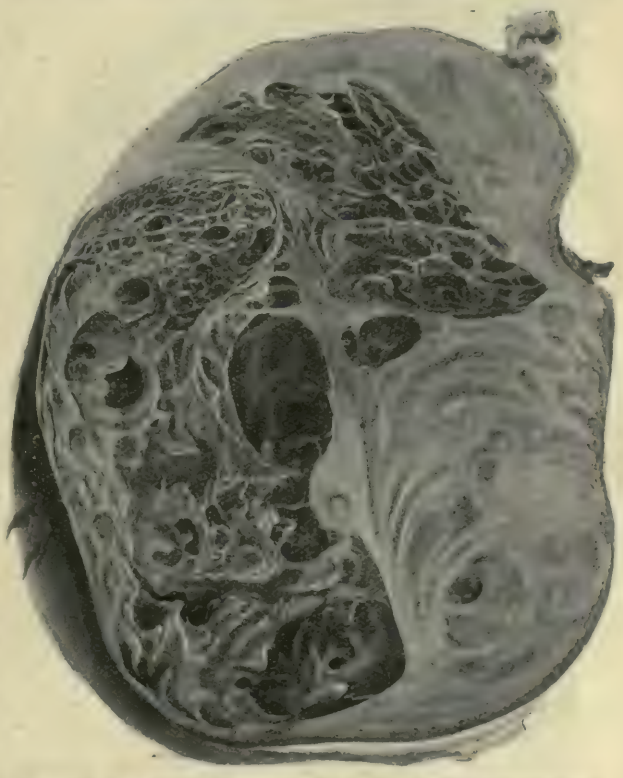


FIG. 456.—A uterine fibromyoma showing cystic degeneration. (St. Bartholomew's Hospital Museum.)

*Torsion.* — The pedicle of a subserous myoma may undergo torsion, though this accident is much rarer than in the case of ovarian cysts on account of the shortness and rigidity of the pedicle; as the result of torsion the pedicle may atrophy and the tumour become entirely separated from the uterus. In many cases the symptoms are slight, but if the torsion be acute vessels are occluded and hæmorrhages occur into the substance of the tumour; the symptoms then resemble those of torsion of the pedicle of an ovarian cyst.

Occasionally the whole uterus is rotated to such an extent that the canal is occluded and the cavity becomes distended with menstrual blood or secretions (hæmatometra and hydrometra): should the contents become infected pyometra results.

**Diagnosis.**—A large fibroid or a collection of fibroids which together constitute a large tumour can be detected on abdominal examination, for in the majority of cases the uterus rises out of the pelvic into the abdominal

cavity. The enlarged uterus then forms a tumour in the hypogastrium situated in or near the mid-line of the body. Unless fixed by adhesions or impacted it is movable; its consistence is that of a firm solid; its surface is smooth and regular in the case of a single tumour, or irregular and bossed when multiple fibroids are present. It cannot be made to contract, and except when changes of degeneration are present it is not tender to the touch. On percussion the note over it is dull, and only in the case of very vascular tumours can a bruit be heard on auscultation. Pedunculated subperitoneal fibroids can often be moved independently of the main tumour, but cannot be separated from it to any marked extent.

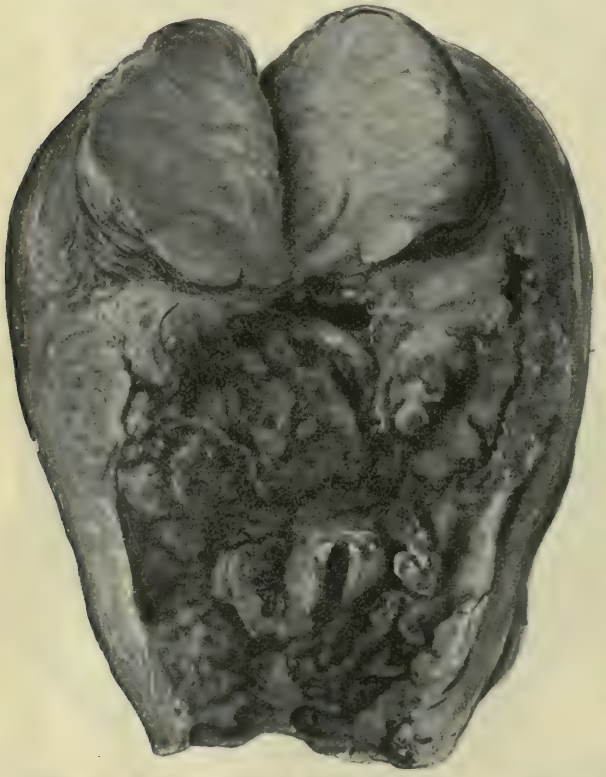


Fig. 457.—Carcinoma of the body of the uterus complicated by a fibromyoma. (St. Bartholomew's Hospital Museum.)

On vaginal examination if a polypus be present it is felt as a rounded tumour occupying the vaginal vault; when the polypus is completely extruded the cervix is but little dilated and a narrow stalk can be traced passing into the canal, but when the polypus is in process of extrusion the cervix is patent and forms a ring encircling the partly-extruded tumour. If the fibroid occupies the abdominal cavity the cervix is drawn up and in many cases is difficult to reach, but if the fibroid is in the pelvis the cervix may be displaced forwards, backwards, or to one side, according to the situation of the tumour. A fibroid fails to rise out of the pelvis when it is impacted beneath the promontory of the sacrum, when it grows between the two layers of the broad ligament, or when it is fixed by adhesions, and under any of these conditions will be felt as a hard, solid, insensitive tumour occupying some part of the pelvic cavity and displacing the pelvic viscera.

*On bimanual examination* the growth will be identified either as the enlarged uterus or as a tumour closely connected with it. If one hand be placed on the abdomen over the tumour and the fingers of the other hand upon the cervix it is found that movements imparted to the tumour are conveyed to the cervix, and *vice versa*.

*The passage of the uterine sound* helps to distinguish the body of the uterus from tumours in close association with it, and since many fibroids cause elongation of the uterine cavity the sound often passes more than the normal

2½ inches. It is, however, important to remember that subperitoneal and intramural fibroids do not necessarily lengthen the cavity, and that if the uterus be stretched over a parovarian or intraligamentary ovarian tumour the length of the cavity may be increased.

**Fibroids and child-bearing.**—The presence of fibromyomata is no bar to conception, and in many patients pregnancy, labour, and the puerperium run a normal course in spite of these tumours. Women with fibroids are, however, less likely to become pregnant than those with normal uteri, but if the ovum has once become implanted there is little tendency to abortion or premature labour. During pregnancy severe pressure symptoms may develop, particularly if the fibroids are situated low down in the uterus and become impacted in the pelvis; malpresentation of the child is common, for the tumour may displace the head and prevent it from entering the pelvis. Fibroids may obstruct delivery and necessitate the operation of Cæsarean section, or may cause severe post-partum hæmorrhage by interfering with the normal detachment of the placenta and by preventing retraction of the placental site.

During pregnancy the tumours often increase in size and become softer and less clearly defined, but usually again diminish with the involution of the uterus; the frequent association of necrobiosis with pregnancy has been already noted.

During the contractions of labour the tumour may be expelled from the uterine wall and subsequently be passed per vaginam, or may be so damaged by pressure of the child that it may slough and, becoming infected with pathogenic organisms, give rise to a fatal septicæmia.

Fig. 458.—Cervical fibromyoma complicating pregnancy. (St. Bartholomew's Hospital Museum.)

**Treatment.**—Fibromyomata which give rise to no symptoms do not require treatment. When the symptoms are trivial and the patient complains only of a slight increase in the amount of blood lost at the menstrual period, of dysmenorrhœa, of occasional frequency or difficulty of micturition, or of slight deterioration of the general health, but is still able to lead an active and useful life, treatment by rest at the time of the periods and the administration of drugs such as ergot or styptol may be employed. This line of treatment is particularly adapted to patients approaching the time of the menopause. When the hæmorrhage is profuse, when the pain is constant or

severe, when the general health is gravely affected, or when dangerous pressure symptoms are present operation should be advised.

We must remember that fibromyomata are prone to undergo pathological changes which directly endanger the patient's life and that these changes may occur years after the menopause; this fact renders unjustifiable the expectant treatment formerly so commonly adopted, a treatment which resulted in a life of semi- or complete invalidism and was attended by disastrous results to the general health. The operations now undertaken for the removal of these tumours are amongst the most successful and the most satisfactory in the whole range of surgery, but care and judgment are required both in selecting cases suitable for operation and in determining what form of operation should be practised.

When on account of intercurrent disease, such as diabetes, Bright's disease, or a valvular cardiac lesion, surgical interference is inadvisable, the tumour may often be made to shrink and hæmorrhage be lessened or arrested by the application of X-rays to the abdomen or the insertion of radium into the cavity of the uterus. These methods should not be adopted in the case of degenerating fibroids or of fibroids complicated by tubal inflammation, and it is advisable that before employing them uterine curettings should be microscopically examined to exclude malignant disease.

The variety of operation adopted depends upon the situation and size of the tumour. In all cases where practicable a conservative operation should be performed on women who have not reached the menopause, for after enucleation of a fibroid the function of the uterus may be preserved and pregnancy and parturition run a normal course. A submucous fibroid may be enucleated by vaginal operation after dilatation or division of the cervix; an interstitial or subperitoneal fibroid will call for an abdominal incision. After dividing the tissues which form the capsule the tumour is shelled out of its bed by the finger, assisted, if necessary, by a few cuts with the scissors; the cavity left after its removal is obliterated by buried catgut sutures and the edges of the capsule trimmed and united by separate sutures.

Unfortunately, because of the presence of multiple tumours, of disease of the adnexa, or of the impossibility of controlling hæmorrhage, in many cases the uterus has to be sacrificed, but even then an ovary should be conserved.

Abdominal hysterectomy may be total or subtotal; in total hysterectomy the cervix as well as the body is removed, in subtotal hysterectomy the cervix and usually the lowest portion of the body are left. There has been much controversy regarding the respective merits of the two operations, but where practicable the cervix should be preserved.

## Carcinoma of the Uterus.

Carcinoma may involve the cervix or the body of the uterus.

### Carcinoma of the Cervix.

**Frequency.**—The Registrar-General's returns for five years show that during this period 19,645 women died of cancer of the womb. They show further that cancer is commoner in the uterus than in any other part of the body, and that in one-third of the women who die from cancer the uterus is the organ affected.

**Etiology.**—*Age.*—Cancer of the cervix occurs most commonly between the

ages of thirty-five and fifty. It has been found in a child of nine, and is not uncommon in women of advanced age.

*Child-bearing.*—The great majority of women who suffer from carcinoma of the cervix have borne children. It is commonest amongst women who have had large families. Amongst *nulliparæ* the disease is rare.

*Trauma.*—Since the cervix is inevitably injured to a greater or less extent in labour, it has been supposed that injuries inflicted during child-birth are the predisposing cause of the cancerous growth; such relation is not clearly established. Child-bearing leads to other changes in the cervix, infections are common, and may persist for months or years; it is probable that long-continued irritation is a more important factor than mechanical injuries.

*Heredity* is not a factor of importance. A family history was obtained in 8·1 per cent. of 934 cases investigated.

Carcinoma arises from epithelial cells, and in the cervix uteri two types of epithelium are found. The portion projecting into the vagina is covered by several layers of squamous cells resting upon vascular papillæ; the cervical canal is lined by a single layer of columnar cells, and racemose glands, lined by high columnar cells, open into it. Corresponding to these two types of epithelium we find two varieties of carcinoma—squamous-celled carcinoma and columnar-celled or adeno-carcinoma.

FIG. 459.—Squamous-celled carcinoma of the cervix uteri. (St. Bartholomew's Hospital Museum.)

Of the two types the *squamous-celled* is the commoner, constituting 85 per cent. of the cases. The epithelial structures which form the essential part of the growth are seen as irregular masses and strands of cells invading the fibro-muscular stroma of the cervix; the tissues persist for a time to form a supporting stroma for the cancer cells, but eventually the stroma is destroyed, and the growth is composed entirely of epithelial cells, often in a state of degeneration.

In *adeno-carcinoma* the cancer cells are arranged in the form of irregular branching tubes, in which the lumen is lined by several layers of atypical columnar cells; but whether the cells be arranged in solid cords and masses, as in the squamous type, or in anastomosing tubes, as in the columnar type, the epithelial elements invade deeply the surrounding tissues, destroying and not merely displacing them. Tissue invasion is the surest proof of malignancy we possess. Besides growing downwards into the deeper tissues, the cancer forms papillary projections on the surface; the projections consist at first of buds of epithelium only, but later a connective-tissue stroma

carrying the blood-vessels grows into them. They increase rapidly in size, and may form eventually a tumour which occupies the greater part of the vagina. The microscope reveals marked variations in the characters of the cells; they vary in size; their shape is irregular, and often bears but little resemblance to that of the physiological prototype. The most striking changes, however, are seen in the nucleus, which is large, stains deeply, and shows evidence of rapid proliferation in the presence of mytotic figures. The term " anaplasia " is applied to these variations from the normal in the cell characters.

Sooner or later degenerative changes occur as the result of a deficient

Fig. 460.—Microscopic section of squamous-celled carcinoma of the cervix uteri.

blood supply; coagulation necrosis, fatty and hyaline change, and microbic infection result and are marked clinically by the advent of an offensive discharge.

## Morbid Anatomy.

(*a*) *Squamous-celled carcinoma* arises on the surface of the portio vaginalis, but since in multiparæ the squamous epithelium extends for a varying distance up the cervical canal, squamous-celled carcinoma may arise above the level of the os externum. In the earliest stages, most commonly near the margins of the os we find a circumscribed area, more vascular and of darker colour than the surrounding tissue; the patch feels hard and gritty, and when touched bleeds readily. Tumour formation, infiltration, and disin-

tegration progress simultaneously; in some cases the surface proliferation is marked, and a tumour is formed; in others the deeper parts of the growth proliferate, producing infiltration of the surrounding tissues; whilst in a third group disintegration leads to the formation of an ulcer. In the more advanced stages of the disease we therefore recognise three types of growth:—

(1) with tumour formation;
(2) with infiltration;
(3) with ulceration and excavation.

*With tumour formation.*—The upper part of the vaginal canal is occupied by an irregular warty growth. The growth may be attached to a limited area of the cervix, or may lead to an enlargement of the whole portio vaginalis; the surface of the tumour is fissured and covered with small sloughs, the tissues are friable, and free hæmorrhage follows examination.

*With infiltration.* — In this variety the cancer produces hardening and thickening of the tissues of the portio vaginalis. The induration may be confined to one lip, or may form a ring involving the whole circumference; the tissues are reddened, hard, and bleed freely on touch. Occasionally the mucosa appears to be intact, but more often a number of small ulcers are seen on its surface.

*With ulceration.*—This variety is seen first as a raised flattened growth, usually confined to one lip. The growth is soon replaced by a flat ulcer with sharply-defined raised margins and a friable, indurated base which soon becomes deep and crater-like.

FIG. 461.—Intra-cervical columnar-celled carcinoma of the cervix uteri.

Squamous-celled carcinomata invade early the cellular tissue in which the cervix is embedded; they spread also on to the vaginal walls, but their growth in an upward direction is usually limited by the os internum; there are, however, many exceptions to the last statement.

(*b*) *Columnar-celled carcinoma* arises from the cells lining the cervical canal or from the glands. When the cancer commences high in the cervical canal it is found first as a nodule deep in the tissues; from this focus the growth spreads and may involve the whole cervix before ulceration and disintegration take place. The growth invades early the surrounding cellular tissues and spreads outwards into the vaginal vault, but only rarely down the vaginal walls. The body of the uterus is often invaded, and isolated patches of growth may be found near the fundus.

### The Spread of Cancer to Neighbouring Structures.

**The parametric cellular tissue** is collected mainly around the cervix, but processes pass outwards in the bases of the broad ligament to the lateral walls of the pelvis, backwards in the utero-sacral ligaments to the anterior aspect of the sacrum, and forwards on either side of the bladder. In it the ureter runs forward to open into the bladder, passing within ½ inch of the cervix, and the uterine artery with its accompanying vein and lymphatic trunks passes to the uterus. In carcinoma of the cervix this tissue is invaded early; Wertheim found involvement in 65 per cent. of his cases; the bases of the broad ligaments are invaded first, later the utero-sacral ligaments, and the cellular tissue between the bladder and cervix. The effect of such extension is to fix the uterus, and in advanced cases masses of growth can be traced outwards as far as the pelvic walls.

**The vaginal walls** are commonly involved in squamous-celled cancer, the growth spreading from the cervix to the vaginal vault and thence downwards towards the vulva. In the columnar-celled variety involvement of the vaginal walls is a later phenomenon.

**Bladder.**—The base of the bladder is in close relation to the cervix, separated from it by a thin layer of cellular tissue only. As the growth advances, the bladder wall is involved, and carcinomatous nodules, pushing the mucosa in front of them, may be detected by the cystoscope. Eventually the mucosa is invaded also, and as the result of ulceration a cervico-vesical fistula may form. The urethra is seldom involved, though retention of urine may result from compression by the growth.

**Ureters.**—Dilatation of both ureters is commonly found at operation; the obstruction causing the dilatation is more often due to compression of the ureter than to actual invasion of its walls. Above the obstruction the dilatation extends up to and involves the pelvis of the kidney, leading to the formation of a hydro-nephrosis, and, if infection with pyogenic organisms supervenes, to pyo-nephrosis.

**The ovaries and Fallopian tubes** are frequently fixed by inflammatory adhesions, and are invaded by the cancer in about 10 per cent. of the cases; hydro- or pyo-salpinx is found occasionally.

**Body of the uterus.**—The cervical canal, particularly in elderly women, may be obstructed by the growth, and the uterine cavity is then dilated by retained secretions which are frequently infected. Invasion of the body is rare in the squamous-celled type, but not infrequent in the columnar-celled variety.

**The rectum** is involved less commonly than the bladder, for the rectum and cervix are separated one from another by Douglas's pouch. The growth reaches it along the utero-sacro ligament, and may lead to the formation of a recto-vaginal fistula; in advanced cases the vagina may form a "cloaca," into which both rectum and bladder open.

**Blood-vessels.**—Direct invasion of the walls of the blood-vessels is sometimes found. Compression and occlusion of veins is common, and is marked clinically by œdema of the legs and vulva.

**Nerves.**—The great trunks of the sacral plexus are often involved, and this fact accounts for the intense pain which often accompanies the later stages of the disease.

**Lymphatic glands.**—The lymphatics of the cervix arise in the mucous membrane, traverse the muscular wall, and unite to form large trunks which, following the course of the uterine artery, terminate in the iliac glands. Other

trunks pass backwards in the utero-sacral ligaments to the pre-sacral glands, whilst occasionally some pass to the obturator glands; in addition, isolated lymphatic glands are occasionally found in the parametric tissue. In carcinoma the glands most frequently infected are those of the iliac group. It has been shown by Shauta that the glands nearest the tumour may escape and more distant ones be involved; there is but little relation between the size of a tumour and the extent of glandular involvement. Wertheim found cancerous glands in 30 per cent. of the cases submitted to operation.

*Visceral metastases* are not common, and at autopsy are found in only 20 per cent. of the cases; the lungs and the liver are the organs most often affected.

## Symptoms of Carcinoma of the Cervix.

In the earlier stages the symptoms are few and slight. It is impossible to lay too great stress upon this fact; scarcely any disease is more insidious in its onset, and there is none in which early recognition is of more vital importance; to wait for defined and pronounced symptoms before making a thorough and complete investigation is to wait too long. In the earlier stages there is usually one, and only one, symptom—*hæmorrhage*. Later, discharge, pain and cachexia are present, and in the last stages the symptoms vary with the viscera affected by the spread of the growth.

*Hæmorrhage.*—In the majority of cases the first symptom noticed by the patient is hæmorrhage. The bleeding is not always of the same type, but is often noticed first after coitus; this is a symptom so suspicious as always to call for immediate investigation. In some cases the bleeding is first noticed after introducing a douche-nozzle, after straining at stool, or when the cervix is touched during a vaginal examination. The importance of bleeding on mechanical irritation cannot be exaggerated, and it may be laid down as a rule for practice that whenever the cervix bleeds freely on touch, a piece should be removed for microscopical examination. Occasionally excessive loss at the menstrual periods is the first symptom, but this is less common; it is metrorrhagia rather than menorrhagia and frequent small losses rather than severe hæmorrhages which mark the earlier stages, but as ulceration advances the bleeding becomes more profuse and clots are passed. In elderly women bleeding is as a rule not so marked or so early a symptom as in those still within the child-bearing period of life.

*Discharge.*—At first the discharge is clear, mucoid and inoffensive; it soon becomes thicker, more yellow, and streaked with blood. When the surface of the growth is ulcerated the discharge is profuse, watery, offensive and sometimes peculiarly irritating, causing redness and soreness of the vulva.

*Pain.*—The earlier stages of the growth of cancer are usually painless. Severe pain suggests that the growth is no longer confined to the cervix, but has spread into the tissues around; the pain is usually referred to the sacrum or to the hypogastrium immediately above the os pubis. In advanced cases the pain is spread over a wide area, reaching up as high as the umbilicus and shooting down the thighs as far as the knees, often preventing the patient from sleeping at night; it is sometimes relieved for a time by free hæmorrhage or by a copious discharge of pus. Pain may be caused by obstruction of the cervical canal leading to the formation of a hæmato- or pyo-metra, or the bladder or urethra may be involved, causing painful micturition. Thrombosis of the iliac or femoral vein may cause severe pain, and finally salpingitis

and pyo-salpinx, common complications of the later stages, are painful affections.

*Constitutional symptoms.*—Often the patient's general appearance gives no indication of the grave malady from which she is suffering; she may look "the picture of health," but sooner or later she becomes anæmic, and loses flesh. These symptoms are due in part to hæmorrhage and in part to toxæmia caused by the presence of the ulcerated growth. The complexion is sallow, the tongue furred, the breath sometimes offensive, the pulse increased in rate, and the temperature often a little raised. Anorexia and vomiting are not uncommon, and obstinate constipation is sometimes a troublesome symptom.

These four—hæmorrhage, discharge, pain, and cachexia—are the classical symptoms of carcinoma of the cervix. Hæmorrhage and discharge are early symptoms; pain and cachexia suggest an advanced stage.

As the cancer spreads neighbouring viscera are involved, and new groups of symptoms arise.

*Urinary symptoms.*—Cystitis is a common complication. It may be due to infection from the septic mass in the vagina, or may be the first symptom of invasion of the bladder. As the growth advances the vesico-vaginal septum is invaded, and tissue destruction may lead to the formation of a vesico-vaginal fistula with incontinence of urine. The urethra is seldom invaded, but may be obstructed by extension of the growth along the anterior vaginal wall. Serious consequences arise from compression of the ureters as they lie in the parametric tissue; the portions above the obstruction are dilated, the pelves of the kidneys distended and hydro-nephrosis produced. Infection by pyogenic organisms follows, and suppurative pyelonephritis may terminate in uræmia.

*Rectal symptoms.*—The first symptom of invasion of the rectum is a frequent desire to go to stool, with the passage of small quantities of mucinoid discharge. When the mucosa is ulcerated blood and pus may be passed with the motions, pain on defæcation is often severe, and persists for some time after the completion of the act. If a recto-vaginal fistula is formed, incontinence of fæces results; more rarely intestinal obstruction arises from occlusion of the bowel lumen.

*Duration of the disease.*—The average duration of the disease from the commencement of the symptoms is eighteen months. In some cases the progress is much slower, and patients have lived for five, six, or seven years.

*Modes of death.*—Death is most often due to exhaustion brought about by constant discharge, repeated hæmorrhage, and a profound toxæmia. Uræmia is often the terminal event, and may be preceded by anuria for three or four days. Septicæmia, pyæmia, embolism, pneumonia, and general peritonitis are rarer causes.

## Physical Signs and Diagnosis.

The conditions found on physical examination vary with the stage of the disease and the variety of growth. In the advanced stages diagnosis scarcely admits of doubt; in the earlier stages it is sometimes difficult. It must be remembered that carcinoma may be detected either as a tumour or an ulcer, that it usually bleeds freely on touch, and that the tissues of the growth are friable. Where the diagnosis is in doubt a piece of tissue consisting of both mucous membrane and fibro-muscular stroma should be removed for microscopical examination, and care must be taken that the piece of tissue is from

the portion of the cervix under suspicion. In the earlier stages the evidence of disease discoverable on examination is only slight—the cervix may be a little enlarged, it may be unduly hard and present a small raised red patch, or one may detect fine papillary processes projecting from the surface; but whatever form the growth takes it bleeds freely on touch. At this stage no thickening or fixation in the fornices is found, and the uterus is movable unless fixed by inflammatory adhesions. When the disease is more advanced the upper part of the vagina is occupied by an irregular warty growth attached to one or both lips; the growth is friable, breaking down easily when touched, and if seized by a volsellum the instrument tears readily through the tissues. At a later stage the tumour is ulcerated and necrosed, and a crater-like ulcer with irregular excavated base and indurated edges can be felt. The growth may still be limited to the cervix, but often spreads down to the vaginal walls and outwards into the bases of the broad ligament, in which event the fornices are hard and the mobility of the uterus is but slight. In the last stages the vault of the vagina is represented by a hard, nodular, excavated mass; the cervix can no longer be recognised, the growth has spread on to the vaginal walls, and the parametric tissues are invaded and fixed. In some cases the whole of the pelvic viscera are embedded in a mass of cancer, whilst occasionally from fistula formation the rectum, vagina, and bladder open into a common "cloaca."

When a growth is situated higher in the cervical canal the physical signs may be misleading. The greater part of the cervix may be destroyed by ulceration but the portio vaginalis be preserved as a shell of apparently healthy tissue; if, however, the cervix be seized by a volsellum, the shell tears away, and an ulcerated cavity is revealed.

**Differential diagnosis.**—*Simple and traumatic ulceration.*—In prolapsus uteri ulcers are often found on the portio vaginalis. Such ulcers are flat; there is no new growth, the edges are neither raised nor everted, and there is little or no hæmorrhage on examination.

*Erosion, eversion, and hypertrophied cervix.*—In the so-called erosion of the cervix the many-layered squamous epithelium which normally covers the portio vaginalis is in part replaced by a single layer of columnar cells. The condition is often associated with cervical lacerations, inflicted during labour, and with a glandular overgrowth rendering the cervix nodular and hard. When these three conditions are present the physical characters of a carcinoma may be simulated; there is, however, no hæmorrhage on examination and no infiltration or fixation of surrounding parts. In suspicious cases a piece should be removed for microscopical examination.

*Cervical polypi* form small, pedunculated growths attached to the lower part of the wall of the cervical canal and project through the os externum. They are deep red, not friable, and bleed but slightly on handling. They seldom give rise to difficulty in diagnosis, but occasionally an early carcinoma assumes a polypoid form closely resembling that of a mucous polypus.

*Fibroid polypi* in process of extrusion may become gangrenous; the portion projecting through the partially-dilated cervix is then irregular and ulcerated. The sloughing tissues are friable, and may give rise to an offensive discharge and to free bleeding. The clinical picture of a carcinoma is thus simulated, but on vaginal examination we find that the tumour is surrounded and constricted by a ring of healthy cervical tissue.

*Syphilis of the cervix.*—A primary sore may be situated on the cervix uteri; it forms a shallow ulcer with a sloughy base, and gives rise to but little discharge and to no hæmorrhage. The diagnosis is often rendered

clear by the presence of constitutional symptoms—headache, anæmia, rash, general enlargement of lymphatic glands, and superficial ulceration of the fauces. In cases of doubt the demonstration of the spirochæte in smear preparations, or the presence of a positive Wassermann reaction, helps to settle the diagnosis.

Condylomata are occasionally found on the cervix during pregnancy, and are usually associated with condylomata of the vulva and anus. Gummata of the cervix have been described by Winter and Ruge and form sharply-defined ulcers with serpiginous margins and a base covered by vascular sponge-like granulations.

*Tubercle.*—Tuberculous ulceration of the cervix has on many occasions been mistaken for carcinoma. The cervix is indurated and enlarged, the surface hard and nodular with areas of deep ulceration, the tissues friable and necrotic. Diagnosis without the aid of the microscope is often impossible, but there is usually absence of bleeding on vaginal examination. Tubercle bacilli can seldom be demonstrated in the discharge.

## Treatment.

The records of results of treatment in carcinoma of the cervix are disappointing. We recognise three distinct groups of cases :—

1. Cases in which, so far as we can tell by clinical examination, the growth is limited to the tissues of the uterus. In this group the uterus may be removed either by vaginal or by abdominal section.

2. A group in which the disease is so advanced that to remove the whole growth is an impossibility : in such cases palliative measures only should be adopted.

3. Where the growth has spread beyond the limits of the uterus, but its removal is still possible by an extensive operation. The limits of this group cannot be clearly defined ; in any given case the question first arises, Can we reasonably hope to benefit the patient by an attempt to remove the growth ? and, if this be answered in the affirmative, what operation offers the best prospect of a cure ? These questions must be considered separately.

**Cases suitable for operation.**—To determine whether complete extirpation is possible we must ascertain to what extent the surrounding tissues are involved. We consider first the condition of the cervix and vaginal walls : if the cervix be completely destroyed and the fornices extensively involved palliative measures only should be adopted ; involvement of the anterior fornix is of more serious import than involvement of the posterior fornix, for it renders the separation of the bladder impossible. The condition of the parametrium is ascertained by rectal and vaginal examination ; in the normal state the uterus is a mobile organ and by means of a volsellum the cervix can be drawn down to the vulval orifice. So long as the cancer is confined to the tissues of the uterus its mobility is not impaired, but when the growth extends into the cellular tissue the uterus is more or less fixed and the cervix can no longer be drawn down. Whilst the uterus is held down by a volsellum the fornices should be explored by the finger in the rectum, when if the cellular tissue in the bases of the broad ligament be invaded induration will be felt.

If the vaginal walls are not involved, if the cervix can be drawn down to the vulval orifice, if no induration be detected in the broad and utero-sacral ligaments, the operation may be performed by either the vaginal or abdominal route.

When the growth is more advanced and the parametric tissues are indurated the case is unsuitable for vaginal hysterectomy by the usual method and is preferably treated by the abdominal route. It must be remembered that induration does not necessarily imply extension of the growth, but may in part be due to inflammatory exudation.

What degree of extension contra-indicates the radical operation? To this question no definite answer can be given; every surgeon must be a law unto himself. It may be said in general terms that when induration can be detected along the whole base of the broad ligament, or when the bladder is involved, no operation should be undertaken.

**Choice of operation.**—In very early cases good results are obtained by vaginal hysterectomy, but the method possesses certain disadvantages:—

1. It allows the removal of only very little of the parametric tissues.
2. It does not permit the examination of the lymphatic glands.

For these reasons the majority of operators have abandoned the procedure, excepting where the condition of the patient renders a severe and prolonged operation inadvisable. The operation has recently been modified and extended by Schuchardt. In Schuchardt's operation the uterus, upper part of the vagina, and the parametric cellular tissues are removed. The patient is placed in the lithotomy position, and after cauterising the surface of the growth an incision is made along the left wall of the vagina commencing above at the level of the cervix, and terminating below in the left labium majus at its posterior fourth. In this incision the vaginal mucosa and the paravaginal cellular tissue are divided: the cut is now extended outwards and backwards $\frac{3}{4}$ inch external to the anus and terminates in the ischio-rectal fossa midway between the tip of the coccyx and the tuber ischii. The labium majus, the superficial perineal muscles, branches of the inferior hæmorrhoidal vessels and nerves, and part of the levator ani muscle are thus divided. The wound gapes widely, and a good view is obtained of the cervix and vaginal fornices. A circular incision is made round the whole circumference of the vaginal wall at the junction of its upper and middle thirds, and the upper third is dissected off from the bladder in front and the rectum behind. The tube of vagina thus separated is stitched over the cervix, so that the growth is surrounded by a sheath of vaginal wall and does not come into contact with the raw surfaces of the wound. The bladder is separated from the cervix and the vesico-uterine fold of peritoneum opened; the ureters are separated widely and as much as possible of the parametric tissue removed with the uterus: after removal of the uterus the peritoneal cavity is closed and the anterior and posterior vaginal walls united by suture. Finally, the incision in the vagina, labium, and ischio-rectal fossa is also closed by sutures.

**Wertheim's operation.**—This operation differs from abdominal hysterectomy as formerly performed in two essential respects:—

1. When removed the cervix is enclosed by a cuff of vaginal wall, so that the cancer is never in contact with the raw surfaces of the wound.
2. A systematic removal of the pelvic cellular tissue.

*The operation.*—For three or four days before the operation the patient is given a vaginal douche of 2 per cent. formalin solution night and morning, and immediately before operation the vagina is plugged with strips of gauze soaked in the same solution; these strips are withdrawn in the course of the operation immediately before the vagina is cut across, and by this procedure escape of septic material out of the cut vagina into the abdominal cavity is prevented. The patient is placed in a high Trendelenberg position and the

abdomen opened by an incision extending from the top of the symphysis pubis to the umbilicus. The edges of the wound are then protected by a layer of thin Keith's sheeting carefully sewn over them, and the wound is kept open by a good retractor. The uterus is grasped and drawn up into the wound and the omentum and intestines carefully packed off with pads; the ovario-pelvic fold on either side is then divided between clamps and the ovarian arteries thus secured. The round ligament on either side is next dealt with in a similar fashion, being divided a short distance below its attachment to the uterus. An incision is now made through the peritoneum covering the anterior aspect of the uterus and is continued outwards on either side on to the broad ligaments. The large peritoneal flap thus formed is separated from the uterus by blunt dissection and the dissection carried down into the cellular tissue between the bladder and vagina. The next step is the identification of the ureters; they are found most easily where they cross the brim of the pelvis in front of the sacro-iliac articulations, and must be traced forwards to the point where they enter the parametric tissue in the base of the broad ligament. In this procedure care should be taken not to strip them bare from the sheath of cellular tissue which surrounds them, for if thus deprived of their blood supply they are liable to slough.

The uterine vessels are now secured. The uterus is drawn over to one side and the ureter of the opposite side identified where it enters the base of the broad ligament. The index finger is pushed along the ureter through the parametric tissues towards the bladder until the tip of the finger is in close proximity to that viscus. The ureter now lies below the finger, whilst above it is a thick strand of tissue in which are embedded the uterine artery and veins. Whilst held in this position two ligatures are passed beneath the strand of tissue by means of an aneurysm needle and are tied—the outer as near the pelvic wall as possible, the inner nearer the uterus; the tissues are then divided between the ligatures and the uterine vessel in this way secured. The procedure is repeated upon the opposite side.

After division of the uterine vessels the vesical portion of the ureter becomes accessible and must be detached from the vaginal walls; this is done by the finger, aided, if necessary, by the scissors. Sometimes the ureter has to be dissected out from the growth, but, as already pointed out, invasion of its walls is not common. The next step is the division of the posterior layer of peritoneum and separation of the vagina from the rectum. The uterus is drawn forwards over the symphysis pubis, the utero-sacral ligaments divided, and the peritoneum forming the floor of Douglas's pouch divided by a transverse incision close to the uterus. The vagina is then separated by the finger from the anterior wall of the rectum. The upper part of the vagina is now completely isolated from its attachment and, if the uterus be drawn strongly upwards towards the umbilicus, is seen as a sheath enclosing the cancerous cervix: a pair of large right-angled clamp forceps is applied to the vagina below the lowest part of the growth, the bladder and ureters being carefully protected during the application of the clamp. When locked the forceps encloses the whole circumference of the vaginal walls, and the vaginal tube is cut through on the distal side of the clamps. Next, as much as possible of the parametric tissue in the base of the broad ligament is removed; the mass is clamped on either side with angular forceps and then divided with scissors. It is important to remove as much as possible of this cellular tissue, for it is in this region that spread of the growth is most likely to occur. All vessels are now ligatured and the clamps removed. After the bleeding has been stopped the removal of the lymphatic glands may be undertaken; the peri-

toneum is stripped off the external and common iliac arteries, and the glands which lie between the artery and the vein are removed. The vagina may be partly closed by sutures or may be left open and a gauze drain placed in the cellular tissue, the end being drawn down into the vagina. The anterior and posterior flaps of peritoneum are then sewed together over the gauze drain if one has been introduced.

Sufficient time has as yet scarcely elapsed to allow of a final judgment upon the value of Wertheim's operation, but it is probable that this operation offers a greater freedom from recurrence than any other practised at the present time. The operative mortality is unfortunately high, not less than 10 per cent.

*Treatment by radium.*—Favourable results have been obtained in carcinoma of the cervix from treatment by radium. A large quantity, preferably about 150 milligrammes, or its equivalent in emanation, should be used; the tubes which contain the radium should be inserted into the vagina and packed off carefully by strips of gauze from the bladder and the rectum. The portion of the tubes which contains the radium should be in close contact with the cervix: each application should last for twenty-four hours, and the treatment should be repeated at intervals of from four to six weeks, according to the reaction produced.

It is not justifiable at the present time to trust entirely to the action of radium without removing the growth, but whether further advances will render operation unnecessary is a question which only time can answer. In inoperable cases radium undoubtedly relieves the symptoms, prolongs life, and improves the general health of the patient.

## Carcinoma of the Body.

**Frequency.**—Carcinoma of the body of the uterus is a less common condition than carcinoma of the cervix. Approximately 20 per cent. of uterine cancers arise primarily in the mucous membrane of the body.

**Etiology.**—*Age.*—Carcinoma of the body is usually a post-climacteric disease, and is most frequent between the ages of fifty and sixty.

*Child-bearing.*—The disease is commoner in women who have not borne children than in those who have, in this respect offering a marked contrast to carcinoma of the cervix.

*Association with uterine fibro-myomata.*—Attempts have been made to show that the presence of fibro-myomata predisposes to the development of carcinoma of the body. The two conditions may coexist in the same uterus, but there is no evidence that their association is more than a coincidence.

**Varieties.**—Three varieties may be recognised:—

1. Columnar-celled carcinoma;
2. Adenoma malignum;
3. Squamous-celled carcinoma.

The first variety is the commonest; instances of the second and third are rare.

**Columnar-celled carcinoma.**—We distinguish two types—the circumscribed and the diffuse. In the circumscribed type the growth arises from the surface of the mucosa, and is seen first in the form of fine papillary processes projecting into the cavity; sometimes two or more independent growths are found on the surface of the mucosa. As the growth advances it spreads outward into the muscular walls and simultaneously the finger-like processes proliferate to form a soft, nodular tumour which projects into the

uterine cavity. In the diffuse type the whole surface of the mucosa is affected. There is no proof of the statement often made that the circumscribed form arises in the depths of the glands and the diffuse from the surface of the epithelium. The advance of the growth is accompanied by ulceration and disintegration, sloughs form on the surface, and ulcers result from tissue destruction.

*Microscopic characters.*—Columnar-celled carcinoma may arise from the surface epithelium or from the uterine glands. The malignant cells assume irregular forms, the nuclei show evidence of active division, and the connective tissue is invaded and destroyed. The epithelium becomes many-layered, and by its proliferation new glands are formed possessing a lumen lined by several layers of cubical or columnar cells. The gland grouping varies greatly: we usually find alveoli, irregular in both size and shape, separated by a scanty connective-tissue stroma and lined by several layers of epithelial cells. Sometimes the lumen is completely filled by cells, so that an appearance of solid columns is produced. In late stages the columnar form and glandular arrangement of the cells is lost, and the histological picture becomes one of spheroidal-celled carcinoma.

**Adenoma malignum** is a variety of adeno-carcinoma. It does not form a definite tumour, but the whole mucosa is thickened and presents a porous appearance.

*Microscopical examination* shows glands packed closely together, with their lumina lined by a single layer of columnar cells; the intra-glandular stroma is scanty but shows no evidence of epithelial invasion. The glands penetrate to an unusual depth in the muscular wall, and may be found close beneath the peritoneum. Examination of curettings affords no positive proof of malignancy, but suspicion should be aroused if they contain an unusual amount of muscle showing glandular penetration. In the late stages the histological picture is identical with that of columnar-celled carcinoma.

**Squamous-celled carcinoma of the body.**—This disease is rare, and many of the cases reported as primary squamous-celled carcinoma of the body are instances of extension from a cervical growth or of metaplasia occurring in a columnar-celled carcinoma. In elderly women, in cases of inversion of the uterus, or after the application of caustics, the columnar epithelium lining the body may be replaced wholly or in part by squamous cells, and from such cells a primary squamous-celled carcinoma may arise. The microscopical appearances are like those seen in similar growths of the portio vaginalis.

## Direction of Spread.

Cancer of the body tends to remain for a long time localised to the uterus, but when extension occurs the bases of the broad ligaments and the parametric tissue are first involved. Omentum or intestines may become adherent to the uterus and be invaded by direct continuity.

*Lymphatic invasion.*—The lymphatics of the body of the uterus are collected into two or three main trunks. These trunks follow the course of the ovarian artery, and terminate in a group of lumbar glands which lie on either side of the aorta and inferior vena cava at the level of the lower pole of the kidney. The lymphatics from the uterine cornua follow the course of the round ligament and terminate in the inguinal glands; both groups may be involved in cancer of the body.

**Symptoms.**—The symptoms in the earlier stages are slight and variable. In one patient the earliest symptom is a watery vaginal discharge, in a second

hæmorrhage, and in a third pain. It is difficult to draw a clinical picture, for there is no history which can be considered typical.

*Hæmorrhage* is not so marked as in cancer of the cervix; nevertheless, the first symptom may be a sudden and profuse loss of blood repeated after an interval of as long as a month or six weeks. Slight hæmorrhages are of common occurrence, and may be noted after muscular exertion or on defæcation.

*Vaginal discharge.*—A watery vaginal discharge, occasionally blood-stained, is often the first symptom noted. Later the discharge becomes thick and yellow or of a dark colour from the presence of fragments of sloughing tissue; its odour is offensive and penetrating, it is irritating to the skin of the vulva, and may cause pruritus.

*Pain* is an earlier symptom than in cancer of the cervix, though in rare instances it is absent throughout the course of the disease. It is felt most severely in the sacral or hypogastric regions, is constant and aching in character, and worse by night than by day. One type of pain which Pozzi regards as almost pathognomonic of carcinoma of the body is paroxysmal, the paroxysms occurring at regular intervals in the day. Such crises have been attributed to painful uterine contraction excited by the presence of the tumour.

*Cachexia.*—In the early stages the patient's health may suffer but little; later she becomes anæmic and emaciated.

*Other symptoms.*—When the growth invades the peritoneal cavity there is distension and tenderness of the lower abdomen, sometimes associated with vomiting. Ascites may be present, rectal and bladder symptoms follow the spread of the disease to these viscera, and uræmia, usually without convulsions, may result from renal infection.

*Duration of the disease.*—Cancer of the body progresses slowly, and may for months remain limited to the uterus, offering in this respect a marked contrast to cancer of the cervix. Metastatic deposits and lymphatic invasion are both late phenomena.

**Physical signs and diagnosis.**—When the growth is but little advanced abdominal examination usually reveals nothing abnormal. At a later stage abdominal tenderness may be detected, and the inguinal lymphatic glands may be enlarged; occasionally the uterus forms a tumour sufficiently large to be felt in the hypogastrium.

On vaginal examination the cervical canal is usually closed, but may be patent, and if the finger be introduced a friable mass may be felt in the uterine cavity. Examination often provokes hæmorrhage. In the earlier stages the uterus is but slightly, if at all, increased in size, but as the growth advances it becomes larger; at first its regular form is preserved, but later it is irregular and fixed. Great caution must be exercised in the use of the uterine sound in suspected cases, but by its aid valuable information can be obtained; hæmorrhage caused by its passage is a suspicious symptom, and if the walls feel irregular, soft and friable the suspicion is confirmed. It is evident, therefore, that, whilst in advanced cases the physical signs are clear, in the earlier stages, when the diagnosis is all-important, they are few and little marked. In any doubtful case the cervical canal must be dilated and the uterine cavity explored, either digitally or by the curette; by this means alone can a positive diagnosis be made.

*Microscopical examination of curettings.*—There is usually no difficulty in forming an opinion as to the innocent or malignant nature of the tissue removed by the curette. The material is often abundant, and the fragments

are large and friable: on microscopical examination an unusual quantity of muscle is found; the glands are atypical, their form is irregular, they are often branched, and some are lined by several layers of epithelium. The interglandular connective tissue is scanty, and the epithelial cells are not separated from it by a basement membrane.

**Differential diagnosis.**—In cases of hæmorrhage and discharge the first step in diagnosis is to ascertain their source. Such conditions as a foreign body in the vagina, a fibroid polypus projecting through the cervix, or malignant disease of the cervix or vaginal walls may be excluded by digital examination. The following conditions, however, may in some instances be difficult to distinguish from carcinoma of the body:—

1. Cancer commencing high in the cervical canal may in its early stages present signs and symptoms identical with those of carcinoma of the body. The site of the growth can be determined only after the canal has been dilated.

2. Fibro-myomata. A fibroid may cause hæmorrhage and discharge after the menopause. It may undergo malignant change; it may become extruded into the uterine cavity; it may calcify and cause ulceration of the tissues which separate it from the uterine cavity; or it may suppurate or become gangrenous. Any of these changes lead to hæmorrhage and discharge, and the diagnosis from carcinoma may be impossible until the cavity of the uterus is explored.

3. Sarcoma of the uterus may give rise to signs and symptoms identical with those of carcinoma. The diagnosis can in many cases be made only by microscopical examination.

4. Tuberculosis of the body of the uterus is rare; it has been described in a woman of fifty-seven, and caused a blood-stained vaginal discharge accompanied by loss of flesh, but no pain; the uterus was enlarged. The diagnosis in such a case can be made only by microscopical and bacteriological examination.

5. Senile endometritis is a term applied to a condition occurring in elderly women in which the normal lining of the uterine cavity is replaced in part by granulation tissue and in part by flattened epithelium. Clinically it is marked by a purulent discharge, often blood-stained, and pain, sometimes severe. It seldom leads to enlargement of the uterus.

**Treatment.**—The treatment of carcinoma of the body of the uterus is total extirpation of the organ. If the growth is limited to the uterus the operation offers good hope of permanent cure, but when it has spread beyond the limits of the organ, or when the glands are involved, the prognosis is extremely grave. The mobility of the uterus and the extent of the growth must first be ascertained by the methods already described; if the case be a favourable one the choice of operation will depend upon the condition of the patient, the size of the uterus, and the capacity of the vagina. If the uterus be but slightly enlarged and the vagina of average size, vaginal hysterectomy will be the operation of choice in patients who are old, feeble, or very obese. It must be remembered, however, that in many instances the patients are elderly nulliparæ, in whom the vagina is usually so small as to make the necessary manipulations almost impossible. For the majority of cases abdominal hysterectomy with removal of the ovaries and tubes is the best operation. Some surgeons prefer the combined method—commencing the operation by closing the cervical canal with sutures to prevent escape of cancerous material or discharge from the uterine cavity, then separating the vaginal fornices and freeing the bladder as in vaginal hysterectomy, and

after this has been done opening the abdomen and completing the operation by that route.

*Radium.*—The treatment of cancer by radium is still on its trial, and it is impossible to foresee at present to what extent its use may modify the surgery of pelvic cancer. Carcinoma of the body is particularly susceptible to the action of radium rays, but whether it is justifiable to treat an operable case by the application of radium without resorting to operation is a question at present unsettled. The cervix must be dilated and the radium tubes introduced directly into the uterine cavity. Even in inoperable cases such procedure is often attended with great benefit to the patient, the hæmorrhage and discharge ceasing, the pain being lessened, and the patient's general health improved.

## Inflammation of the Fallopian Tubes.

Inflammation of the Fallopian tubes is always of infective origin. The infecting organisms may reach the tube by three different routes :—

1. **As an ascending infection from the uterine cavity.**—This is the commonest mode of infection ; the organism may travel by direct tissue continuity, as in gonococcal infections, or through the lymphatics of the tubal and uterine mucosa, as in the streptococcal and staphylococcal infections associated with labour and the puerperium. In rare instances when the cervical or vaginal canal is obstructed the uterus becomes distended with retained secretions, and bacteria-laden fluid may be forced directly into the tubes.

2. **As a descending infection from the abdominal cavity.**—This is the mode of infection in many cases of tubercle, the disease of the tubes being secondary to tuberculosis of the peritoneum. It may occur also in diseased conditions of the intestinal walls or of the vermiform appendix ; adhesions are contracted with the Fallopian tube, which is subsequently invaded by intestinal bacteria. Actinomyces occasionally reaches the tube directly from the bowel.

3. **Through the blood-stream.**—In septicæmia the Fallopian tubes share in the general infection. In typhoid, pneumococcal and tuberculous salpingitis, the infective organisms are sometimes conveyed by the blood-stream.

**Morbid anatomy.**—In acute inflammation the peritoneal surface of the tube is reddened and injected, loses its lustre, and is often coated by flakes of lymph. The mucosa is swollen, hyperæmic, and exudes a serous or seropurulent fluid which may escape through the abdominal ostium and give rise to a local or in some cases a general peritonitis. On microscopical examination the vessels are engorged, the surrounding tissues are infiltrated with leucocytes, and the epithelial lining in places is shed.

The tube may recover completely from this stage, but more often permanent changes are produced in its walls. The abdominal ostium is closed by adhesion of the fimbriæ to one another, the tissues of the wall are deeply infiltrated by inflammatory products which later undergo organisation into fibrous tissue, and the whole tube is thickened, coiled upon itself and adherent to the ovary, the uterus and other peritoneum-clad surfaces in its neighbourhood. Owing to closure of the abdominal and uterine ostia the tube may become distended with pus or with serous fluid, forming in the one case a pyo-salpinx, in the other a hydro-salpinx. A pyo-salpinx is a thick-walled sac, narrow at its uterine end, but gradually increasing in diameter and most distended in the neighbourhood of the abdominal ostium. The size varies within wide

limits ; it may contain only a few drops of pus or may contain several ounces, in the latter event forming a large tumour. A pyo-salpinx often contracts adhesions to the uterus, the rectum, the pelvic floor or to coils of intestine, and such adhesions add greatly to the difficulty and dangers of its removal by operation. In long-standing cases the infecting organisms perish, probably killed by the accumulation of the products of their own activity, and the pus then proves sterile on culture. The infection may be unilateral or bilateral, or we may find a pyo-salpinx on one side and a hydro-salpinx on

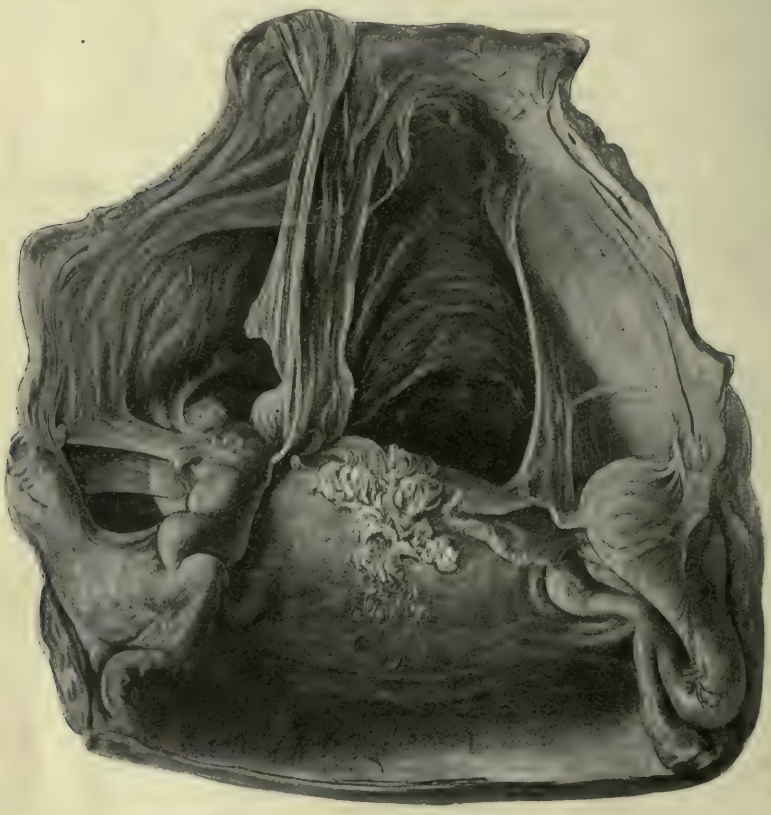


FIG. 462.—Bilateral salpingo-oöphoritis showing a small pyo-salpinx on the left side and adhesions to adjacent viscera. (St. Bartholomew's Hospital Museum.)

the other. If the infecting organism be of low virulence or the tissue resistance be high, the tube may be distended by serous fluid instead of pus, with the formation of a *hydro-salpinx*. The sac of a hydro-salpinx is usually thin-walled, the fluid is clear and watery and the tumour translucent. The shape is very characteristic : the tube, coiled upon itself, is but little dilated at the uterine end, but its calibre gradually increases towards the abdominal ostium, and at its extremity it is distended into a globular or ovoid sac ; the form of the tumour thus resembles that of a retort with a convoluted delivery tube. As a rule the adhesions around a hydro-salpinx are few and easily separated. With closure of the ostium important changes occur in the plicæ of the tubal mucosa ; neighbouring folds adhere to one another, so that a

number of closed cavities bounded by plical folds are formed within the lumen (*salpingitis pseudofollicularis*). As the tube becomes more distended the plicæ atrophy and finally only traces of them may be found flattened close to the wall.

A pyo-salpinx may rupture or may undergo spontaneous cure. Rupture occurs most frequently into the bowel, less often through the posterior vaginal fornix, the bladder, or into the general peritoneal cavity. When the infecting organisms have perished, the pus may be slowly absorbed and the tubal cavity contract until eventually it is obliterated. It is important to remember, however, that a sterile pyo-salpinx may at any time be reinfected by the passage of intestinal bacteria through the wall of adherent bowel.

The ovaries are always involved in cases of tubal inflammation, and, except in the early and acute stage of the infection, ovary and tube are adherent to one another. As the Graafian follicles rupture and discharge their ova a wound is formed through which the infecting organisms readily gain admission to the follicular cavity, and it is common to find small abscesses scattered through the ovarian cortex corresponding in their position to the corpora lutea. In cystic ovaries the cyst contents may be infected and a tubo-ovarian abscess be formed.

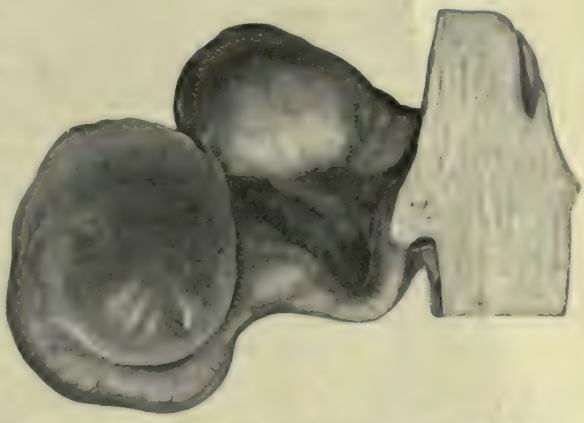


Fig. 463.—Hydro-salpinx. Left tube. (St. Bartholomew's Hospital Museum.)

**Symptoms.**—It is difficult to define the symptoms of salpingitis, for the disease is usually preceded by endometritis and is invariably associated with oöphoritis and pelvic peritonitis; hence we do not know which symptoms are to be attributed to the salpingitis and which to the associated lesions. In acute cases the illness is of sudden onset, with a raised temperature, a rapid pulse, furred tongue, and general malaise; vomiting may be present at an early stage, and rigors are sometimes met with. Pain in the lower abdomen is usually acute; it may be more or less localised to one iliac fossa or may be felt generally over the whole hypogastrium; it is often, colic-like, worse on movement and on deep inspiration.

The lower abdomen is held rigidly, and on attempts at palpation the recti and other abdominal muscles become so tense and firm that it is impossible to feel the structures beneath them. Vaginal and bimanual examination usually yield but little information. There is marked tenderness in the vaginal fornices, and a tumour may be discovered in the region of one or both tubes. If the examination be made after the third or fourth day of the illness the pelvic peritoneum will be thickened by inflammatory exudation and form a rigid board-like sheet, easily felt through the vaginal fornices, fixing and rendering immobile the uterus and other pelvic viscera. With the spread of the infection the bladder and rectum are involved, micturition

is frequent and painful, and rectal tenesmus with the passage of small quantities of mucus may cause much distress. As before stated, these symptoms are not to be attributed to the lesion in the tubes, but are those of a localised peritonitis.

In chronic salpingitis two symptoms are present—pain and menstrual disturbance. The pain is felt in the lower abdomen and is often more severe upon one side than the other; it is often referred to the iliac fossa or to the region of the sacrum. It is felt severely during the stage of premenstrual congestion and becomes easier when the flow is well established. It is rendered worse by exertion and is easier after rest; the patients often state that they are comparatively free from pain when they get up in the morning, but as the day advances the pain becomes gradually more severe. When the inflamed tube and ovary are adherent to the rectum the act of defæcation may be painful, and in many cases micturition is frequent and painful.

Salpingitis is usually associated with menorrhagia—the intervals between the periods are shortened, the loss is increased, and clots are passed. In cases of advanced tuberculous disease of the tubes, however, the menses are scanty, and long periods of amenorrhœa are not uncommon. Between the periods there is often a profuse mucous or muco-purulent vaginal discharge, sometimes sufficiently copious to necessitate the use of a diaper. It is uncertain to what extent these symptoms are to be attributed to the lesion in the tube; it is probable that in the majority of cases they depend upon associated inflammation of the endometrium or uterine wall. In many of the chronic cases the tubes are sealed and the patients sterile. Dyspareunia is usually a marked symptom.

The chronic course of the disease is often interrupted by exacerbations; the pain becomes acute, the temperature and pulse-rate rise, the lower abdomen becomes distended and rigid, and the symptoms of a localised peritonitis develop. Such attacks may be caused by the escape of inflammatory products into the peritoneal cavity through the unclosed ostium, by the breaking down of adhesions or by reinfection of the damaged tube by organisms from the bowel. In many cases the acute symptoms subside with a few days' rest in bed but reappear after a longer or shorter interval.

When examined in the quiescent stage the thickened tube can be felt on bimanual examination as a cord stretching from the uterus out towards the lateral pelvic wall or lying in the retro-uterine space; it is fixed by adhesions and possesses very little mobility. In many cases the ovary and tube are matted together and tethered to the back of the uterus, the anterior surface of the rectum, the posterior surface of the broad ligament or the peritoneum of the pelvic parietes (Fig. 462). If distended with pus the tube forms a club-shaped swelling; the isthmus is thickened and but little dilated, forming a relatively thin stem attached to the uterine cornu, whilst the ampulla and infundibulum are increased in diameter and form a tumour situated to one side of or behind the uterus. The tube wall is often so thick and fibrous that the pyo-salpinx feels like a solid tumour and may be mistaken for a subperitoneal fibroid. In hydro-salpinx the tube wall is thin and the tumour is elastic, resembling in its physical characters an ovarian cyst.

**Diagnosis.**—A pyo-salpinx may be mistaken for an ectopic gestation, an inflamed and adherent ovarian cyst, a perimetric exudation, or a subperitoneal fibroid.

**Treatment.**—It may be laid down as a general rule that in acute tubal

inflammations when the lesion is limited to the pelvis and signs of general peritonitis are not present no surgical interference should be attempted. The patient should be confined to bed rigidly, the diet should be light, the bowels should be made to act freely by saline purges, and pain should be relieved by hot applications to the abdomen and the administration of sedative and analgesic drugs, but morphia should be avoided as far as possible. Under this treatment in the majority of cases the severe symptoms subside in the course of a few days; in the acute stage operation is attended with grave danger of a general infection. Should an abscess form and point either beneath the abdominal wall or through the vaginal vault it should be opened and drained, but no attempt should be made to remove the tubes. If symptoms of general peritonitis supervene the abdomen should be opened and drained freely both through the abdominal wall and through the pouch of Douglas, and after operation the patient should be kept in the Fowler position. After the acute symptoms have subsided treatment should be directed towards the absorption of the inflammatory mass in the pelvis. Continued rest in bed, copious vaginal douches twice daily of four to six pints of water at a temperature of 112° F. slowly given, the use of ichthyol tampons, and the oral administration of small doses of mercury and iodide of potassium, together with care in securing a daily evacuation of the bowels, should be tried in all cases before advising operation. This line of treatment gives highly satisfactory results and in many cases saves the patient from the necessity of a mutilating operation.

In chronic cases operation may be rendered necessary (1) because of recurring acute attacks, (2) because of severe pain, (3) because of the effects upon the patient's general health interfering seriously with her duties and condemning her to a life of semi-invalidism. In the first group of cases the operation should not be performed until the temperature and pulse-rate have been normal for some days and the leucocyte count has fallen. The operation may be performed by either the vaginal or abdominal route—each has its advantages and disadvantages—and should be so planned and carried out that if possible one ovary and tube are preserved. In the vaginal operation an incision is made in the anterior fornix, the bladder separated, and the anterior peritoneal reflection incised; the uterus is then brought forward after separating adhesions and the ovaries and tubes examined: if their condition is considered past recovery they are removed, if not the tubes may be opened, scraped out, irrigated, and a new ostium made by stitching the mucosa to the peritoneal coat.

The abdominal operation is the one more usually selected, for it involves less risk of injury to the bowel and other viscera and enables us to ascertain more accurately the condition of the diseased ovaries and tubes. The abdomen is opened by an incision in the middle line, adhesions are separated, and care must be taken not to tear or injure the bowel; should such an accident unfortunately occur the rent must be closed at once. In some instances it is found necessary to remove both tubes and the uterus, but the operation should be as conservative as possible.

## Ovarian Tumours.

1. **Classification.**—Tumours of the ovary can be grouped into broad classes, but it is difficult to draw hard and fast lines between the various groups. We shall describe first the cystic tumours and secondly the solid tumours.

## Cystic Tumours of the Ovary.

1. **Follicular cysts.**—(*a*) *Distension cysts* arise in the Graafian follicles when their rupture is prevented, and are often associated with degenerative changes in the stroma and blood-vessels. They are seldom larger than a golf-ball, and may be single or multiple ; the cyst wall is composed of connective tissue, dense and fibrous in its outer layer, looser and more vascular in its inner layers. In the smaller cysts the wall is lined by a single layer of columnar or cubical epithelium, but in the larger cysts the epithelium is no longer found ; the intracystic fluid, clear and yellow in colour, is derived in part from degeneration of the cells of the membrana granulosa and in part from exudation through the vessel walls. These cysts give rise to no symptoms, and require no treatment.

(*b*) *Lutein cysts* are distinguished by the presence of a layer of yellow lutein tissue in their walls. They are usually multiple, and in the majority of cases both ovaries are affected ; individual cysts may attain the size of an orange, and are occasionally larger than this. The wall is composed of compressed ovarian stroma lined by a layer of lutein tissue with a wavy, folded outline, and on its inner aspect is sometimes found a layer of epithelial cells ; the cell contents may be thick and jelly-like or clear and watery. The larger cysts are associated with a recent pregnancy, and in the majority of cases with a vesicular mole or a chorion-epithelioma ; the life of the lutein cell is short, and where the expulsion of the mole is not followed by the development of chorion-epithelioma the lutein cysts become smaller, and the ovary ultimately shrinks to its normal size.

2. **Cysts of new formation.**—(*a*) *Simple proliferative serous cysts* (cystoma serosum simplex).—These tumours are the simplest form of new growth found in the ovary, and probably originate either from developmental remains or from downgrowths of the surface epithelium ; the proliferation of the epithelium is but little marked, but its secretory activity is great, and consequently the cysts are distinguished by the relatively large amount of fluid they contain and the scanty amount of epithelium lining their wall ; as the tumours enlarge from the accumulation of fluid, cell proliferation is sufficiently active to provide a complete epithelial investment. They are seldom so large as to cause pressure symptoms, but frequently attain the size of an orange ; they are usually unilateral, possess a thin translucent wall, and are filled with clear serous fluid of low specific gravity.

(*b*) *Pseudo-mucinous cyst adenoma* is the variety of ovarian tumour most commonly met with clinically ; it is an innocent growth and is usually pedunculated, but occasionally burrows into the broad ligament, separating its two layers.

The tumours sometimes attain an enormous size ; the surface is of a white colour, and shows rounded elevations corresponding to loculi in the interior of the cyst ; the vascular supply is rich, and large blue veins are seen shining through the smooth outer wall. On section we see a number of loculi separated by fibrous septa to which are attached clusters of daughter cysts ; the relative proportions of fluid and of solid material vary, for in some specimens the tumour consists of a honeycomb-like mass with small cavities, whilst others possess only a single loculus, but their original multilocular character is revealed by the presence of fibrous bands and cords on the inner aspect of the wall, the remains of septa which have been broken down. The surface is originally covered by the superficial epithelium of the ovary ; the outer layer of the wall represents the stretched tunica albuginea and the inner layer

modified ovarian stroma. The cyst is lined by tall columnar epithelial cells each possessing a rounded nucleus situated near its base and containing in its protoplasm albuminous granules and masses of pseudo-mucin; the epithelium is arranged in the form of glands, and is usually single-layered, but sometimes papillary processes project into the cavities. The contained fluid may be thick and viscid or thin and watery; its specific gravity varies between 1,010 and 1,030, and its colour, depending upon the amount of admixture with blood pigments, may be pale yellow or dark brown. It contains albumen and large quantities of pseudo-mucin, a body which can be split up into a carbohydrate and a protein by boiling with mineral acids, but differs from mucin in that it is not precipitated from a watery solution by acetic acid.

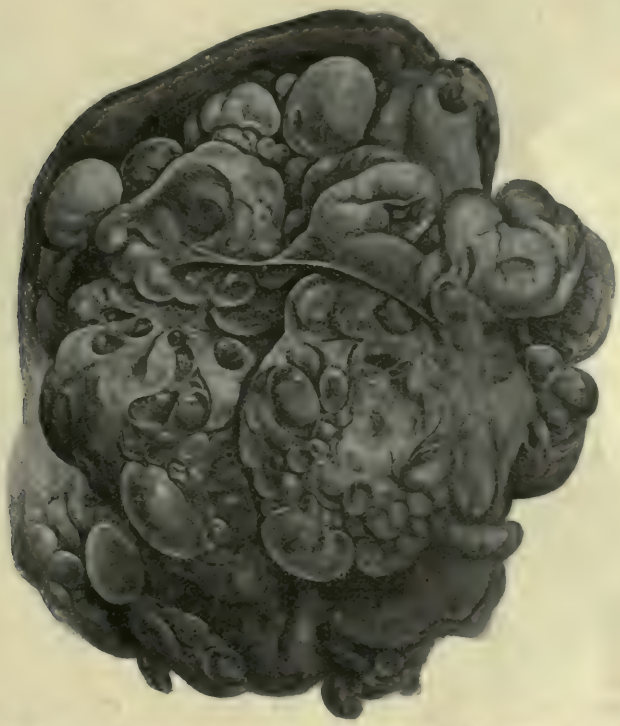


FIG. 464.—Pseudo-mucinous cyst adenoma of the ovary. (St. Bartholomew's Hospital Museum.)

The pseudo-mucinous cyst adenomata usually possess well-marked pedicles, in which branches of the ovarian artery pass to the tumour; more rarely they grow between the two layers of the broad ligament, and, by stripping the peritoneum from the posterior wall of the pelvis, may become retroperitoneal.

They occur at all periods of life, and have been found in an eight months fœtus; they are not uncommon in women of advanced age. They grow rapidly, and often attain a large size within a few months.

*Malignancy and metastases.*—Malignant invasion of the connective tissue wall by the epithelial cells is occasionally found, but whether such tumours were malignant *ab initio* or were originally innocent and have subsequently undergone a malignant change is not definitely known.

*Epithelial infection.*—As the result of rupture of a pseudo-mucinous cyst portions of the lining epithelium may become implanted upon a peritoneal surface or upon the raw tissues of a wound and there grow, reproducing the characteristics of the parent cyst. In such instances masses of pseudo-mucin weighing as much as 40 lbs. have been removed from the peritoneal cavity by repeated operations extending over a period of years.

(*c*) *Papillomatous tumours* of the ovary occur both as excrescences springing from the wall of a cyst and projecting into its cavity and as sessile or pedunculated growths on the surface of the gland. Papillomatous cysts differ from pseudo-mucinous cysts in the following respects :—(1) They are usually bilateral ; (2) they contain papillomatous masses, which, if the cyst wall ruptures, become distributed over the peritoneum and give rise to implantation metastases ; (3) they commonly burrow between the two layers of the broad ligament ; (4) they are unilocular, or consist of only a small number of loculi ; (5) they seldom attain a very large size ; (6) their contents are clear

Fig. 465.—Papilliferous ovarian cyst. (St. Bartholomew's Hospital Museum.)

serous fluid ; (7) the epithelium lining them is often polymorphous. The papillary growths are composed of a connective-tissue stroma and an epithelial investment ; the epithelial cells are usually cylindrical, and sometimes ciliated.

These tumours stand on the border-line between innocence and malignancy : so long as the papillary growths are confined within the cyst walls they behave as benign tumours ; should rupture of the wall occur (a very common event), the growths become planted upon the peritoneum in all parts of the abdominal cavity, but even after this event, if the cyst be completely removed, the implantation growths will shrivel and disappear. When the papillomata become disseminated, ascites rapidly develops.

3. **Teratomata.**—The terms "teratomata" and "embryomata" are applied to a group of neoplasms built up of heterogeneous tissue elements ; the tissues are often well formed and so grouped together as to constitute structures resembling the mature organs of the body. In the ovary two groups of teratomata may be distinguished—teratomatous cysts and solid teratomata.

*Teratomatous cysts* are often termed "dermoids," but this name is incorrect, for they are not inclusion cysts derived from the ectoderm, but contain in addition mesoblastic and hypoblastic structures. The tumour is composed of two parts—an embryonal rudiment in which we can demonstrate tissues derived from all three layers of the blastoderm and a cyst in which this rudiment is growing. They are usually unilateral, spherical in shape, with a smooth, glistening surface, and often of a yellow colour; the cyst cavity is occupied by thick sebaceous material and hair, the sebaceous matter contains cell *débris*, fat globules, and cholesterin plates. They are occasionally incorporated in a pseudo mucinous adenoma. The wall is lined by skin in the immediate neighbourhood of the embryoma, and in this portion of the wall alone hair follicles are found; the remainder of the lining wall is smooth or covered by granulation tissue in which hairs and cholesterin plates are embedded. The embryoma usually projects from the wall into the cavity, but does not always form a distinct eminence; it consists mainly of skin and its appendages, but often contains also flat plates of bone, brain tissue, respiratory or intestinal mucous membrane, retina, and other highly-specialised tissues; teeth are sometimes present in large numbers.

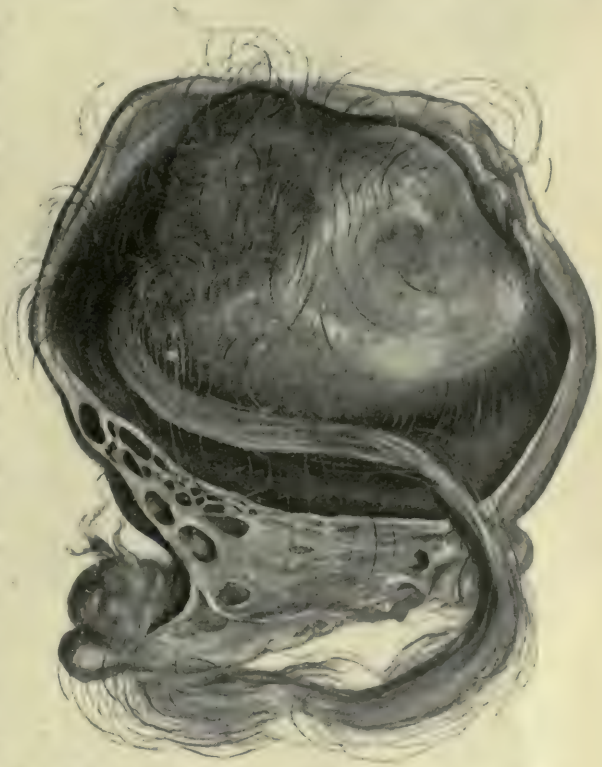


FIG. 466.—A teratomatous ovarian cyst. (St. Bartholomew's Hospital Museum.)

Teratomatous cysts occur at all periods of life; they grow slowly and may remain of almost the same size for many years; in old age they undergo senile changes, evidenced by shedding of the hair and calcareous and hyaline changes in the tissues. If from violence or other causes the cyst ruptures and its contents become scattered over the peritoneum, secondary growths, sometimes reproducing the complex structures of the embryoma, may be found attached to the abdominal viscera. Occasionally squamous-celled carcinoma arises in the skin of the embryoma.

*Solid teratomata* are rare; they differ from the cystic tumours in that they are usually intensely malignant; they are capable of reaching enormous dimensions, and in some instances grow with great rapidity, attaining a large size in a few weeks. They are usually pedunculated, globular with a smooth

or bossed surface, and possess a capsule composed of fibrous tissue and altered ovarian stroma. They are never completely solid, but contain cystic spaces lined by epithelium. Microscopical examination reveals a heterogeneous collection of tissue elements, so grouped together as to resemble the organs of the body. The stroma is composed of fibrous tissue and of cells of an embryonic character. Metastases are common and may be confined to the peritoneum and retroperitoneal lymphatic glands, or may be found in the viscera; they usually consist of sarcoma or carcinoma cells, and rarely reproduce the complicated elements of the parent tumour.

The ovarian teratomata arise from sex-cells, and are possibly instances of parthenogenesis.

4. **Tubo-ovarian cysts.**—When an ovarian cyst and a hydro-salpinx exist coincidentally adhesions may form between the two and later, by absorption of the septum, a single cyst cavity result. A large hydro-salpinx sometimes simulates closely a tubo-ovarian cyst, for, as the result of the pressure of the dilated tube, the ovary becomes incorporated with the tube wall and is indistinguishable as a separate viscus.

## Solid Tumours of the Ovary.

(A) **Benign tumours.**—1. **Fibromata** constitute about 2 per cent. of ovarian tumours. The whole ovary may be replaced by the new formation, or the fibroma may be localised to one part of the stroma, leaving the rest of the ovary unaffected except as the result of compression. Fibromata are seldom larger than a man's head; the surface is smooth, dead-white in colour, and free from peritoneal adhesions; they are pedunculated, and seldom cause separation of the two layers of the broad ligament. Except when degenerative changes have occurred, the growths are densely hard and composed of interlacing bands of white fibrous tissue; the vessels are few, and consist of capillary spaces lined by endothelium and surrounded by concentrically-arranged tissue-fibres; mucinoid degeneration leads to the formation of cystic cavities in the interior of the tumour. In contradistinction to true fibromata we find tumours built up of tissues closely resembling those of the normal ovarian stroma; their capsule is less dense, their surface is often irregular and bossed, they are more vascular and less hard. It is often difficult to decide whether such tumours are innocent or malignant, for the ovarian stroma contains spindle and round cells of the embryonic type, resembling those of sarcomata, and in the case of a tumour composed largely of these elements histological diagnosis is sometimes impossible; many are clinically innocent, for no recurrence takes place after removal, but sometimes rapid dissemination occurs where histological examination has revealed no definite evidence of malignancy. Ovarian fibromata are rare before puberty; they grow slowly, and are often accompanied by ascites.

2. **Fibro-myomata** are rare tumours, and probably arise from the ovarian ligament rather than from the ovary itself. On microscopical examination we find interlacing bundles of unstriped muscle fibres separated from one another by fibrous tissue.

(B) **Malignant tumours.**—1. **Carcinoma** is found both as a solid tumour and in the form of intracystic growths of either the glandular or papillary type. The solid growths are the rarer of the two and are frequently bilateral, but the growth in one ovary is commonly much larger than that in the other. A scirrhous and a medullary type can be recognised. In the *scirrhous* the growth seldom exceeds the size of a fœtal head; the tumours are peduncu-

lated, rounded, dense and hard, but often contain yellow areas of softening and cystic spaces formed by degeneration. The *medullary* type contains but little connective tissue, and the tumour is soft and almost brain-like, the surface is smooth, of a grey or pink colour, and on section areas of fatty and caseous degeneration, hæmorrhages and cyst-like cavities filled with colloid material are common. The tissues are often pigmented, sometimes a dirty grey, and sometimes almost black. Tumours of the medullary type grow more rapidly than those of the scirrhous, and are usually found in younger women.

Microscopic appearances are very diverse. We usually find a glandular arrangement of the cells in the form of simple or branching tubes lined by a single layer of columnar epithelium. The epithelium proliferates, becomes many-layered, grows out into the surrounding connective-tissue stroma, until ultimately the tubes are packed closely together and their lumina filled with masses of atypical cells so tightly compressed that they lose their columnar form and become spheroidal.

*Cystic carcinomata* may be of either the glandular or papillomatous form. They resemble in their naked-eye characters the innocent cysts, but as the growth progresses epithelial masses project into the cavity, the wall is perforated, the cancer spreads to adjacent organs, and metastatic growths are found in the peritoneum and in the abdominal viscera. The fluid contents resemble those of the innocent cysts, but the tissues are friable and tear rapidly during the process of removal. Some are unilocular, but the majority are multilocular. It is not definitely known whether these tumours are malignant from the beginning or whether in their earlier stages they are innocent and subsequently develop malignant characters. In the glandular type there is a typical proliferation of the cyst epithelium, the carcinomatous alveoli become many-layered, and the connective tissue of the wall is invaded and destroyed by the cancer cells. In the papillary type the epithelium covering the papillæ is atypical, polymorphous, and many-layered; it grows inwards towards the cavity and outwards into the connective tissues of the wall.

*Colloid carcinoma of the ovary* is rare. The tumour consists of irregular epithelium-lined spaces filled with colloid material and separated from one another by connective-tissue septa also infiltrated with colloid material.

*Secondary carcinoma of the ovary.*—The ovary is a common site of secondary growths in carcinoma of the uterus, of the breast, and of the gastro-intestinal canal. Some pathologists maintain that most ovarian carcinomata are secondary to growths elsewhere, most commonly the intestinal tract; this view, however, is probably incorrect.

2. **Sarcoma.**—Sarcomata constitute about 5 per cent. of all ovarian tumours, and are less common than carcinomata; in 20 per cent. of the cases the growths are bilateral. They are found at all periods of life, but are most common in young adults, and are relatively frequent in children. They are usually intensely malignant, and metastases are found early in the lumbar glands, the liver and the lungs.

*Spindle-celled sarcomata* are usually round, hard, nodular tumours resembling in their characters the fibromata, and possess a stroma composed of firm fibrous tissue arranged in the form of interlacing strands amongst which lie spindle and fusiform cells. Blood channels are numerous, but their walls contain no muscle and are composed of the tumour cells. They are found as a rule in elderly women. *Round-celled sarcomata* are of softer texture, often brain-like; cystic degeneration is common; hæmorrhages into the tissues and yellow areas of softening are often seen. On microscopical exami-

nation the tumour is composed of round or oval cells with large nuclei, separated from one another by a delicate intercellular stroma. The tumour is very vascular, irregular blood channels lined by sarcoma cells forming a striking feature of the section. They are intensely malignant, and are usually met with in young adults.

3. **Endothelioma** and **perithelioma** are varieties of sarcoma, and arise from the endothelial lining or the lymphatics of the adventitia of the vessels. The cells invade the surrounding tissues in the form of tubular and cone-like masses, so that an alveolar appearance is seen on section. The tumours are less malignant than the carcinomata; but of the recorded cases 25 per cent. have died within a month of operation, and few are known to be alive after five years. Metastases are found in the peritoneum, uterus, vagina, and retroperitoneal glands.

4. **Chorion-epithelioma.**—Primary chorion-epithelioma of the ovary is rare, but it has been recorded on several occasions and has been found arising in a teratomatous ovarian cyst, though the majority of cases have followed shortly after a pregnancy. The growth is of a deep-red or bluish colour, and on section a mottled hæmorrhagic mass is seen, covered by a thin capsule of ovarian tissue. The malignancy of the growths varies greatly; in most instances death has occurred within a few months of operation, but in some cases the patient is alive and well years after the removal of the growth.

**Symptoms.**—The symptoms of an ovarian tumour in its earlier stages are often few and slight, and the patient may seek advice on account of a gradual and painless enlargement of the abdomen. *Menstruation* is usually unaffected, but amenorrhœa is met with in cases of bilateral growths. *Metrorrhagia* occurs in a small percentage of cases, and in women past the menopause uterine hæmorrhages, sometimes profuse, are occasionally seen.

*Pain* is most often caused by pressure of the tumour, but may result from inflammation, from torsion of the pedicle, or from rupture. A comparatively small cyst impacted in the pelvis may cause a severe pain from pressure on the cords of the sacral plexus.

*Ascites* is common in the case of solid tumours and of malignant or papillomatous cysts: *œdema* of the legs, abdominal walls, and vulva may result from pressure by large innocent growths, but marked œdema, particularly if unilateral, is suggestive of malignancy.

With large tumours *dyspnœa* on exertion and *orthopnœa* are common.

*Dyspepsia* from pressure and interference with the functions of the stomach and intestine is often an early symptom.

*Urinary symptoms.*—Retention of urine is much rarer than with uterine fibromata, for an ovarian cyst usually rises above the pelvic brim, but if it becomes impacted the uterus is pushed forwards and the neck of the bladder may be compressed between that viscus and the symphysis pubis. The ureters may be compressed in the case of intraligamentous cysts; the proximal portion is then dilated, the pelves of the kidney are distended and hydronephrosis results. Death may occur from suppression of urine.

*Rectal symptoms.*—A cyst situated in the pelvis may press upon the rectum, causing obstinate constipation and painful defæcation. An inflamed or suppurating cyst may cause mucous diarrhœa from rectal irritation.

*General symptoms.*—With a large ovarian tumour the patient's general health suffers—she loses flesh, becomes anæmic, and in some cases emaciated.

**Physical signs and diagnosis.**—It is convenient to discuss the diagnosis first of small tumours situated in the pelvic cavity, and secondly of large tumours situated above the pelvic brim.

(A) **Tumours in the pelvic cavity.**—At first the small ovarian tumours lie behind the broad ligament in one or other posterior quarter of the pelvis, but as they enlarge they sink to a lower level and occupy the retro-uterine space, displacing the uterus forwards. If a tumour be intraligamentary it lies to one side of the uterus, pushing it over towards the opposite pelvic wall. The tumour is globular or oval in shape; most cystic tumours are smooth and elastic, but the teratomata are inelastic and doughy; solid tumours are often lobulated and irregular on the surface. With the exception of the intraligamentary cysts, ovarian tumours are attached to the uterus by a pedicle, and the recognition of this pedicle is an important aid in diagnosis. The first step is to ascertain whether the tumour be distinct from or part of the uterus; with pedunculated tumours this is usually not difficult, but with an intraligamentary cyst great difficulty may be experienced. The tumours which offer most difficulty in diagnosis are :—

*Swellings of the Fallopian tubes*, hydro-salpinx, pyo-salpinx, and tubal gestation. The diagnosis of these tumours is considered elsewhere.

*Uterine tumours.*—In the earlier stages of pregnancy the body of the uterus forms a globular swelling, whilst the lower segment is so softened that the connexion between the cervix and body cannot always be easily ascertained. A history of amenorrhœa and vomiting, signs of activity in the breasts, and softening of the cervix usually make the diagnosis clear, but in doubtful cases a second examination a few weeks later will settle the point. A retroflexed gravid uterus forms a cystic swelling behind the cervix, but the presence of the signs and symptoms of pregnancy and the absence of the uterus from its normal situation serve to distinguish it from an ovarian cyst.

*Uterine fibromyomata* move as a rule with the uterus. They are solid tumours, and a sense of fluctuation can rarely be obtained.

*Exudates* in the retro-uterine space, whether of blood, serum or pus, may be mistaken for an ovarian cyst, but such collections of fluid are irregular in outline and possess no mobility.

(B) **Large ovarian cysts occupying the abdominal cavity.**—The first step in the diagnosis is to recognise the existence of a definite tumour and to ascertain that the enlargement of the abdomen is not due to obesity, flatulent distension of the bowel, or to ascites. Tumours which may be mistaken for ovarian cysts are :—(1) *A distended bladder :*—this can always be distinguished by the passage of a catheter. (2) *Tumours of the uterus*, pregnancy, uterine fibroids, or hæmato-metra: in these conditions on bimanual examination the uterus cannot be distinguished apart from the tumour; there is usually a history of menstrual disturbance, either amenorrhœa or menorrhagia, and the physical characters of the swelling differ from those of ovarian tumours. (3) *Renal tumours.*—It is possible to mistake a movable kidney for an ovarian tumour if its mobility be sufficiently great to allow it to descend and lie over the brim of the pelvis; a hydro-nephrotic kidney may simulate an ovarian cyst, and in cases of large tumours the diagnosis may be difficult. The chief points of distinction are :—that the renal tumour occupies a more lateral position, that no direct connexion can be traced between it and the uterus, and that on percussion there is a band of resonance over the anterior surface due to the presence of the colon. (4) *Pancreatic cysts.*—Cysts of the pancreas form fluctuating tumours beneath the left costal margin, and as they enlarge the stomach and liver are displaced upwards, the transverse colon downwards, and the anterior surface of the great omentum is stretched in front of the tumour. Such growths seldom extend to the pelvis; both

ovaries can be palpated on examination and no pedicle attaching the tumour to the uterus can be felt.

Other tumours which may be mistaken for ovarian cysts are—mesenteric and retroperitoneal cysts of doubtful origin, a greatly distended gall-bladder, a dislocated and enlarged spleen, an encysted collection of fluid in peritonitis, an ectopic gestation sac, and an echinococcus cyst.

**Diagnosis of malignancy.**—The diagnosis of malignancy in an ovarian tumour rests partly upon the symptoms it causes and partly upon the physical characteristics of the growth.

*Cachexia.*—Large innocent tumours lead to loss of flesh and cachexia, but if these symptoms are present with small or medium-sized growths they are suggestive of malignancy. *Ascites* and *œdema* are met with in large innocent cysts, particularly those of a papillomatous type, and with solid tumours, but if the ascitic fluid collects rapidly, or if œdema of the legs, labia, and lower abdominal wall is marked, and particularly if unilateral, the growth is probably malignant.

*The presence of metastatic growths and the fixation of the tumour.*—In their earlier stages malignant tumours are movable; later from invasion of surrounding structures they are fixed and rendered immobile. Fixation is one of the later signs of malignancy, and indicates that the growth is no longer confined to the ovary.

*Involvement of rectal and vaginal mucosa.*—If the mucosa of either the rectum or vagina is found firmly fixed to the tumour, such a condition is suggestive of invasion.

**Complications.**—*Torsion of the pedicle.*—The pedicle of an ovarian cyst may become twisted, either gradually or suddenly. Gradual torsion is as a rule not accompanied by symptoms, but from interference with their blood supply the vitality of the tissues is diminished and degenerative changes or microbic infection from the bowel are apt to result. The causes of sudden torsion of the pedicle are often difficult to determine; in some cases it has followed trauma, but pregnancy and labour are amongst the commonest causes; the degree of torsion varies from a twist through a quarter of a circle to one causing two or three complete turns of the pedicle. When torsion is complete and sudden the tumour is enlarged from vascular engorgement and discoloured from effusion of blood into both the cavity and the cyst walls. The patient is seized with sudden severe pain in the abdomen associated with the symptoms of shock, pallor, subnormal temperature, and a feeble pulse; vomiting is not uncommon. The shock is greatest when there is much hæmorrhage into the tumour. Soon the abdomen becomes distended and tender, the pulse-rate and temperature are raised, the tongue is furred, the movements of the abdomen are restricted, the signs of a localised or general peritonitis are present, and the tumour increases in size from effusion of blood.

*Rupture of the cyst* may occur either spontaneously or as the result of trauma; spontaneous rupture is the commoner, and occurs most often in papillomatous cysts. The signs and effects of the rupture depend in part upon the nature of the cyst contents and in part upon the rapidity with which they escape; the escape of small quantities of serous or myxomatous fluid causes no symptoms, and the accident may be discovered only at operation, but the sudden escape of large quantities of fluid may be attended by profound shock, by violent pain, and by vomiting and abdominal distension. If large veins are torn across in the capsule severe internal hæmorrhage may result, or, if the contents be purulent, septic peritonitis may develop.

On examination changes will be discovered in the condition of the abdomen. The tumour is smaller and flaccid, or has disappeared entirely: whilst at the same time free fluid is detected in the peritoneal cavity. If the fluid be thin and serous, it is rapidly absorbed and excreted by the kidneys and bowel; if thick and tenacious, it is absorbed only slowly or not at all. Implantation metastases following rupture of papillomatous or teratomatous cysts have already been described.

*Inflammation of the cyst.*—Inflammation is most prone to occur in cysts whose vitality has been lowered either from torsion of the pedicle or from injuries received during labour; the source of infection is most commonly the bowel, but may be through the blood-stream, through the Fallopian tube, or from an adherent appendix. Inflamed ovarian cysts contract adhesions to surrounding viscera and to the parietal peritoneum: such adhesions tend to fix the tumour, and may give rise to intestinal obstruction.

*Suppuration.*—Suppuration of an ovarian cyst is a grave complication. In some instances the symptoms are slight, and there is a remarkable absence of both fever and pain, but more often both severe constitutional and local symptoms are present. The temperature rises, the pulse-rate is increased, the tongue becomes furred and dry, there is obstinate constipation, and the skin often becomes yellow. The tumour is not necessarily tender so long as the peritoneal coat is not involved, but abdominal pain and tenderness are marked features. A suppurating cyst may rupture into the small or large intestine or into the bladder, it may burst through the pouch of Douglas and the pus escape from the vagina, or may point beneath the anterior abdominal wall.

**Treatment.**—As soon as an ovarian cyst is diagnosed it should be removed: to this rule there are but few exceptions. An ovarian cyst is a constant source of danger to the patient; she is liable at any time to torsion of the pedicle, to rupture or to inflammation or suppuration of the cyst; and it is often impossible to be certain whether the tumour is innocent or malignant. In the child-bearing period of life an ovarian tumour may obstruct labour. Small cysts may be removed either by the abdominal or by the vaginal route; large tumours can only be removed by an abdominal incision. Details of the various methods of operation will be found in text-books of operative surgery.

## Ectopic Gestation.

Under normal conditions the ovum and spermatozoon meet in the Fallopian tube, and the earlier stages of development are accomplished there; after impregnation the ovum travels towards the uterus and becomes embedded in the uterine mucosa. The cause of ectopic gestation is but little understood. In some instances the ovum is mechanically prevented from passing into the uterus by tumours, by inflammatory adhesions, or by pathological changes in the wall of the tube. In other instances the ovum has developed in a diverticulum of the tubal mucosa or in an accessory tube which did not communicate with the uterine cavity, but there are many cases in which none of these conditions are found. Ectopic gestation may occur at any period of child-bearing life, in the primipara shortly after marriage or in the multipara approaching the time of the menopause; it is not uncommonly preceded by a period of sterility, but such a history is by no means constant.

**Classification.**—The fertilised ovum may be arrested at any point between

the ovary and the uterine cavity; an ectopic gestation may therefore be ovarian, abdominal, tubal, or, when the ovum is situated in the undeveloped horn of a bicornute uterus, cornual. Of these varieties tubal gestation is the commonest, constituting 85 per cent. of all cases.

1. **Tubal gestation.**—The ovum may be implanted in any portion of the Fallopian tube, but is most commonly found in the ampulla. By the destructive action of its trophoblast it bores its way into the mucosa and there embedded develops into a fœtus and its membranes. The tube wall possesses but little power of hypertrophy, and as the ovum grows becomes stretched and thin. Simultaneously the mucosa undergoes changes, scattered groups of decidual cells are found in its folds, and if the ovum be embedded in the ampulla the ostium is closed by adhesion and contraction of the fimbriæ. The uterus hypertrophies and its mucosa becomes converted into a true decidua which may be separated and expelled at any time during the pregnancy.

The commonest termination of a tubal pregnancy is the formation of a *tubal mole.* As the villi penetrate the tissues separating the ovum from the lumen of the tube the chorio-capsular space is opened and blood escapes into the tube; if the abdominal ostium be patent the blood passes into the peritoneal cavity; if closed it either distends the tube and forms a hæmatosalpinx or leads to rupture. When the abdominal ostium remains patent the mole may escape through it into the peritoneal cavity (tubal abortion), or the abortion may be incomplete, the ovum, though separated from the wall throughout the greater part of its extent, remaining attached at one spot. So long as this condition persists hæmorrhage from the tube wall continues, the blood escaping into the peritoneal cavity.

*Rupture of the tube.*—Rupture is the second commonest mode of termination. It may occur within fourteen days of conception, or, in cases of interstitial gestation, may be delayed until the fourth or fifth month; in the majority of cases it occurs within ten weeks and is usually earlier in isthmic than in ampullary pregnancies. Rupture may be caused by erosion of the walls of the gestation sac by the chorionic villi, by direct violence, as during a pelvic examination, or by a sudden distension of the tube by blood. The site of rupture may be intra- or extra-peritoneal; if intraperitoneal the blood escapes into the peritoneal cavity, if extraperitoneal the effused blood lies between the two layers of the broad ligament.

*Intraperitoneal rupture.*—Hæmorrhage takes place into the peritoneal cavity and may be so profuse as to cause the death of the patient within an hour. The ovum may remain within the tube or may escape through the rent. If the placenta be separated throughout the greater part of its extent the fœtus dies; if the separation be only slight the fœtus (protruded through the rent) may continue to develop in the abdominal cavity, and a new secondary gestation sac is formed consisting of the expended tube and fœtal membrane adherent to intestines and surrounding viscera.

*Extraperitoneal rupture* is a rarer event. The ovum is extruded into the space between the two layers of the broad ligament; if it perish the space is occupied by a mass of blood-clot termed a broad ligament hæmatoma; if it continue to grow the peritoneum is gradually stripped up from either the anterior abdominal or the posterior pelvic wall by the enlarging gestation sac.

*Secondary rupture of the gestation sac.*—The sac of a secondary abdominal or broad ligament pregnancy may rupture at any time between its formation and full term; such ruptures take place into the peritoneal cavity and are

usually fatal. Occasionally after the death of a fœtus suppuration may occur in a secondary gestation sac and an abscess form.

*Development to full term.*—If the secondary sac escape rupture and the child continue to develop, spurious labour ensues at full term. The uterus contracts rhythmically, labour pains are experienced for a day or two and then pass off, the fœtus perishes, the liquor amnii is slowly absorbed, and the fœtus within the abdominal cavity may undergo mummification, calcification, or adipocere formation.

In *interstitial pregnancy* the ovum is embedded in the part of the tube which traverses the uterine wall. In such cases rupture is delayed until the third or fourth month and the event is almost invariably fatal from the great loss of blood.

2. **Ovarian gestation.**—The ovum may be fertilised while still within the Graafian follicle and develop *in situ*. The ovary possesses remarkable powers

FIG. 467.—Ruptured tubal gestation showing perforation of the gestation sac by the chorionic villi. (St. Bartholomew's Hospital Museum.)

of accommodating itself to the growing ovum, and rupture may be delayed for three or four months or even longer.

3. **Cornual pregnancy.**—When the ovum is implanted in an undeveloped uterine horn the muscular wall may hypertrophy and the pregnancy advance to full term, or the hypertrophy may be insufficient and rupture take place; in the former event the patient is unconscious of anything wrong up to the time of labour. The gravid horn seldom communicates with the uterine cavity and delivery per vias naturales is impossible. At term the patient suffers labour pains, sometimes for two or three days, the fœtus dies, the liquor amnii is absorbed, and the gestation sac shrinks.

**Symptoms and signs.**—(*a*) **From conception to the time of rupture of the gestation sac or formation of the mole.**—The symptoms are those of early pregnancy—amenorrhœa, activity of the breasts and morning vomiting. In many cases until the time of rupture there are no indications that the pregnancy is abnormal, but occasionally attacks of abdominal pain due to leakage of blood into the peritoneal cavity and small vaginal hæmorrhages caused by partial detachment of the decidua may be present.

Physical examination may reveal nothing abnormal, but on bimanual examination a tumour, separate from the uterus, may be felt in the situation of one or other broad ligament or in Douglas's pouch. Extreme care must be exercised in physical examination of suspected cases, for it is easy to rupture the thin-walled sac.

*Treatment.*—As soon as the diagnosis of unruptured ectopic gestation is made, the gravid tube should be removed through an abdominal incision, for we do not know how soon hæmorrhage may occur nor how severe it may be. The abdomen is opened by an incision in the middle line, the hand is introduced and the uterus grasped; the fingers now gently palpate each tube and the gravid tube is drawn up into the wound. A clamp is inserted on the broad ligament on either side of the gestation sac and the portion of tube between the two clamps removed; a ligature is applied distal to each clamp and the aperture in the broad ligament closed by sutures. As a rule it is not necessary to remove the ovary, but if the gestation sac is closely adherent it may be impossible to separate them.

(*b*) **With rupture of the sac and formation of a mole.**—The acute symptoms associated with these events are due to hæmorrhage. The severity of the symptoms varies with the amount of blood lost and the rapidity of its escape; if the blood escape rapidly no adhesions form to shut it off from the peritoneal cavity, and the condition is one of *diffuse internal hæmorrhage.* If the blood escape into an enclosed space, as in extraperitoneal rupture, or escape slowly and, trickling down into Douglas's pouch, is shut off from the general peritoneal cavity by adhesions, the condition is one of *encysted internal hæmorrhage.* There is usually no warning of approaching rupture, the patient is suddenly seized with acute pain in the lower part of the abdomen, she is often bent double, and in some instances falls to the ground. The skin is covered by a cold, clammy perspiration; vomiting is not uncommon; the expression is anxious; the pulse frequent and of small volume; respiration is rapid, and the temperature subnormal. If the amount of blood lost is not great the patient soon recovers from the initial shock, but if the bleeding be profuse and continued consciousness is gradually lost and death may occur within half an hour. Simultaneously with or soon after the rupture of the sac there may be an escape of blood from the vagina due to the partial separation of the uterine decidua. The vaginal hæmorrhage is usually slight and continuous, but may be sudden and profuse.

*Treatment.*—If seen at the time of the rupture the abdomen should be opened in the middle line, the hand introduced and the fingers passed along the broad ligament until the gestation sac is reached; the sac is then brought up into the wound, a clamp applied to the ovario-pelvic fold to secure the ovarian artery, and another to the broad ligament between the sac and the uterus, to secure the uterine artery. In this way all bleeding from the ruptured sac is arrested, and the sac is then removed by the method already described. The operation should be performed as rapidly as possible and no time should be wasted in mopping up blood or removing clots from the peritoneal cavity. If the patient be suffering from shock and collapse gum arabic solution should be run into a vein during the operation.

(*c*) **Subsequent to rupture of the sac.**—If the patient survive the accident paroxysms of pain will be repeated if further hæmorrhage occurs, the discharge of blood from the vagina usually continues, and the blood lost is often dark and thicker than the normal. In the course of a few days the uterine decidua is discharged, sometimes complete, sometimes in fragments.

(1) **Pelvic hæmatocele.**—If the ovum perish a hæmatocele forms in

Douglas's pouch, bounded in front by the posterior aspect of the uterus and broad ligaments, behind by the peritoneum covering the rectum and sacrum, laterally by the reflections of peritoneum on to the side walls of the pelvis, and below by the peritoneum of the pelvic floor; it has no definite boundaries above, but is shut off from the peritoneal cavity by adhesions of the omentum and intestines. The uterus is displaced forward, and lies close behind the symphysis pubis; the cervix is low down, and the pelvic excavation is occupied by a rounded tumour, at first fluid and elastic, but later becoming firmer. The hæmatocele is usually slowly absorbed until ultimately no traces of it can be discovered, but as a result of infection from the bowel it may suppurate and an abscess rupture into the posterior vaginal fornix or the rectum. The hæmatocele may be mistaken for a retroflexed gravid uterus: in both cases the signs of pregnancy are present, in both the cervix lies close behind the symphysis and an elastic tumour fills the pelvic cavity, but in the case of a hæmatocele we can usually distinguish the body of the uterus in front of the tumour.

*Treatment.*—If left alone a pelvic hæmatocele is gradually absorbed, but the process is slow and convalescence prolonged. The patient should be kept in bed and carefully watched; if there be repeated attacks of pain or if the swelling increase in size an abdominal operation should be performed. If the temperature rises and other signs of septic infection are present an incision should be made through the posterior vaginal fornix, the decomposing blood-clot removed, and a large drainage-tube inserted.

(2) **Secondary abdominal gestation.**—Should the fœtus survive the rupture of the tube a secondary abdominal gestation results and the signs and symptoms of pregnancy persist; fœtal movements often cause considerable pain, but beyond this nothing unusual may be noticed by the patient until full term is reached. If secondary rupture of the sac occur the event usually happens during the first half of the pregnancy. At full term "spurious labour" supervenes, the fœtus dies, the liquor amnii is absorbed, and the tumour shrinks.

On abdominal examination the sac is felt as a tumour containing a solid body (the fœtus) and fluid (the liquor amnii). The fœtus is situated close beneath the anterior abdominal wall and contractions of the sac cannot be excited by manipulation as in the case of a uterine pregnancy. The uterus can often be felt as a body separate and distinct from an abdominal tumour.

*Treatment.*—During the first half of pregnancy the gestation sac with its contents can often be removed entire through an incision. Its chief blood supply at this period is derived from the ovarian and uterine arteries, and by clamping the ovario-pelvic fold and the broad ligament near the uterus the vessels may be secured before the sac is detached from its surroundings; during the later months the sac obtains a rich blood supply from the omentum and intestines, and in detaching it from these structures the hæmorrhage may be very great. After the death of the fœtus the blood supply gradually diminishes, and two months subsequent to that event the sac can be removed with comparatively little bleeding. Secondary rupture of the sac is a comparatively rare event in the second half of pregnancy, and many operators consider it the safer course to allow the pregnancy to continue to term and some weeks after the spurious labour and death of the fœtus to open the abdomen and remove the placenta and gestation sac entire. It must be remembered, however, that rupture of the gestation sac during the second half of the pregnancy occurs in rare instances, and if it is not thought advisable to

delay operation the best procedure is to open the sac, remove the child, stitch the edges of the incision in the sac to those of the abdominal wound and insert large drainage-tubes. In course of time the placenta will separate and be extruded piecemeal through the abdominal wound. The chief objections to this method of treatment are the long convalescence and the liability to septic infection.

# Section XXVIII.

## GONORRHŒA.

Gonorrhœa is the result of infection of the mucous membranes of the urethra in the male and of the urethra, vagina, and cervix in the female. Other mucous membranes, such as those of the conjunctiva and the rectum, are also liable to become involved. The specific micro-organism is the gonococcus of Neisser (see p. 104). Infection usually occurs during the act of coitus, but exceptionally it may be conveyed through towels, clothes, instruments, etc., which have been contaminated. Alcoholic excess and phimosis are predisposing factors.

### Gonorrhœa in the Male.

It is important to realise that the anatomical conditions of the male urethra take an important part in the spread of the disease In the first place the compressor urethræ divides the urethra into two portions, an anterior and a posterior; a number of glands open into each; in the former the lacunæ, follicles of Littré and Cowper's glands, and in the latter the seminal ducts and the prostatic glands; all are possible sites for complications.

In its onset the disease is a catarrhal inflammation set up by the toxins of the gonococcus, the latter having found its way in between the epithelial cells into the connective tissues, where it sets up a sub-epithelial inflammation. The compressor urethræ, being a very sensitive muscle, speedily passes into a state of spasm as soon as the inflammation spreads to its neighbourhood, thus showing a natural tendency to prevent the onset of a posterior urethritis. When the posterior portion of the urethra, however, does become involved, the neighbouring structures, *i.e.*, the prostate, seminal vesicle, the vas deferens, epididymis and testicle are liable to be attacked. Rarely, the disease passes backwards into the bladder and sometimes extends as far as the kidneys.

In an anterior urethritis, enlargements of the lymphatic glands in the groin, which tend to suppurate when secondary infection takes place, may occur.

With a posterior urethritis a blood infection is a not infrequent complication. The joints, the iris, the fascial tissues, the pleura and even the heart valves may become involved, but these complications are unusual. It is extremely common for gonorrhœa to pass from the acute stage to one of considerable chronicity.

### A. Acute Gonorrhœa.

*Symptoms and signs.*—The incubation period of the disease is from three to seven days, although it may commence as early as the first and as late as the twenty-first.

The patient first complains of meatal irritation, with a burning sensation on micturition. A discharge will be seen issuing from the urethra, at first quite thin and watery and pale yellow in colour. These symptoms increase,

and the discharge becomes thicker and more creamy for a period varying from five to twelve days. The disease then gradually subsides, lasting from three to eight weeks, provided the infection remains localised to the anterior urethra.

The symptoms experienced by the patient during the act of micturition vary; there may be no symptoms, or the pain may be very severe. Tenderness along the urethra into the perineum is experienced, and the lymphatic glands of the groin may become tender, swollen and painful. Nocturnal erections often cause severe pain, and the penis, from the loss of elasticity of the corpus spongiosum, becomes curved downwards (chordee). Under these conditions the discharge is often bloodstained owing to the tearing of the mucosa.

The mucosa at the meatus will be red and swollen, a condition extending for a variable distance along the urethra. Provided there is no posterior urethritis it is unnecessary to examine the other genital organs, with the exception of Cowper's glands, which have their ducts opening into the anterior urethra; if involved, they appear as small, tender swellings in the perineum.

Constitutional symptoms are frequently present; the patient feels ill and has anorexia, and may be exceedingly worried mentally. As the discharge ceases, the general symptoms diminish.

When the infection has spread to the posterior urethra, as it does in 60 per cent. of cases, there will be an alteration in the symptoms. Varying degrees of perineal pain, a temporary subsidence of the discharge with an increased frequency of micturition and a painful termination of the act, and sometimes hæmorrhage, indicate a posterior urethritis. These symptoms are increased when the prostate becomes involved, an event almost always coincident with posterior urethral infection. The appearance of epididymitis confirms the diagnosis.

On examination per rectum the urethra will be tender; the prostate, if involved, will be slightly enlarged and tender; the seminal vesicles may show similar signs. The early recognition of these complications is important, both from the points of view of diagnosis and prognosis, as they indicate the possible onset of epididymitis and the necessity for complete rest in bed. It is during this stage that there is the greatest liability for infection to spread *viâ* the blood-stream to other tissues of the body. The testicles should be carefully examined, any pain, tenderness, swelling, and œdema of the glands or the scrotum being noted. The sudden stoppage in the urethral discharge has often been stated to be indicative of the onset of epididymitis.

*Diagnosis.*—The discharge often collects under a tight prepuce, causing considerable œdema, and, in these circumstances, must be distinguished from that arising from a collection of *débris* around the corona through want of cleanliness, or from some ulcerative condition, such as a soft or hard chancre, or even a growth. Any ulcers or sores on the glans penis or prepuce should be examined for spirochætes to exclude coincident syphilis. If the prepuce becomes very swollen it may lead to a paraphimosis.

The appearance of a penile discharge within a few days of a possible contamination is in the great majority of cases due to gonococcal infection. Any doubt that exists can be speedily resolved by the examination of a film preparation in which the gonococcus can be demonstrated. This confirmatory test should always be performed before other investigations are embarked upon. It now becomes essential to define the extent of the disease, and it is important to prove that it has not already spread into the posterior urethra prior to the patient's attendance for treatment. The patient should appear before the surgeon with a full bladder; the anterior urethra is then irrigated

with a cold solution of oxycyanate of mercury (1 in 6,000), or cold sterile water until the washings return clear. So long as the irrigation tank is not raised more than 3 feet above the level of the urethra and the lotions are cold, there is little likelihood of infection being spread backwards. The patient then passes his water, and if this is clear, the posterior urethra has not yet become infected; and *vice versâ*, if it is turbid and contains pus, as shown by microscopic examination, this must have come from the posterior urethra (two-glass test).

If the meatus can be observed by pulling back the prepuce, the discharge will be seen to be exuding from it. In cases of phimosis so severe that it is impossible to expose the meatus and if the actual source of the discharge is uncertain, the preputial cavity should be irrigated before the above examination is carried out. If it is impossible by either of these investigations to make certain of the origin of the discharge and the gonococcus cannot be demonstrated, then the prepuce should be split or a formal circumcision performed.

If the urine is clear and no discharge is seen, and if gonococci are absent, there is no urethritis.

## B. Chronic Gonorrhœa or Gleet.

*Symptoms and signs.*—The symptoms of this condition are usually trivial; in fact they may be so slight that the patient is not aware that he has any pathological lesion. It is essential at the termination of an acute urethritis to make a complete examination in order to be sure that the disease has really come to an end.

Among the commoner symptoms are an occasional discharge, especially if the patient is taking alcohol, the sticking together of the meatal lips in the morning, and the presence of threads in the urine and urethral irritation. In such cases the meatus should be examined first; the mucosa may appear to be natural, but mucus may be present; the latter should be examined microscopically; warts may be found on the glans penis. The patient should then be instructed to pass his water; threads of mucus will be observed, which should be examined under a microscope; if consisting of epithelial cells only, the condition may be regarded as one of a trivial nature, but the presence of pus cells should be looked upon with suspicion. Too much stress must not be laid on the type of threads which appear in the urine as indicative of the site of their origin. If these threads sink in the urine they probably contain pus, whereas if they are composed of mucus only they will float. This is only a rough test, and should not prevent a microscopic examination being made.

The next investigation consists in carrying out the so-called "four-glass test." The patient appears with his bladder full of urine; the anterior urethra is then washed out with some colourless fluid, such as sterile water or a weak solution of oxycyanate of mercury until the washings come clear. He then passes a portion of his water, which includes the contents of his posterior urethra; the prostate is then massaged and the patient passes the rest of his water, thus obtaining the prostatic secretions. The bladder is then filled up with some clear fluid, and the vesicles, each in turn, are massaged, thus giving the vesicular contents. The deposit from each of these situations is then examined microscopically and bacteriologically. With these observations the site of the pathological lesion can be discovered, but this examination may require to be repeated on more than one occasion.

To demonstrate the type of lesion present in the anterior urethra, the aero-urethroscope should be passed, and infected follicles and Littré's glands, submucous swellings, warts, strictures or leucoplakial patches sought for. The presence of these cannot be detected by any other method.

A similar examination should be made with a posterior urethroscope when there is evidence of a lesion in the posterior urethra; plugged prostatic glands, an œdematous verumontanum and warts may be found in this situation. During the examination of the posterior urethra the prostate and vesicles should be massaged, so that it can be clearly defined from which of these structures pus is coming in the case of prostatitis or vesiculitis. If it cannot be demonstrated that pus is arising from any of these situations, especially if gonococci cannot be found, then a further examination of the urinary tract is called for. The use of the cystoscope, ureteral catheterisation and radiography may demonstrate lesions which would otherwise not be suspected. The main points of diagnosis resolve themselves into :—

1. Threads or pus in the urine demonstrate infection of the genito-urinary tract.
2. The " two-glass test " proves the presence of a posterior urethritis.
3. Pus in the washings after massage of the prostate indicates a chronic prostatitis.
4. Pus or threads in the washings after massage of the vesicles indicates vesiculitis.
5. An anterior and posterior urethroscopy demonstrate the lesions responsible for the pus.
6. The absence of any indication of the presence of a lesion on these examinations calls for a further investigation of the rest of the urinary tract.

In all cases microscopic and bacteriological examination should be made to confirm the clinical evidence.

**Examination of the prostate.**—The prostate should be examined in all cases of posterior urethritis, and is best performed with the patient in the knee-elbow position. There is, as a rule, no enlargement of the prostate, but hard, tender nodules may be felt more or less uniformly distributed throughout its structure. It is thus differentiated from acute prostatitis in which the whole gland is enlarged, and also from an abscess possibly localised to one lobe.

*Massage of the prostate* should not be carried out in cases of acute prostatitis, unless an abscess be present, when a useful purpose may be served by rupturing it into the posterior urethra; this method, however, is only desirable when acute retention demands it; in most cases it ruptures spontaneously.

The main uses of prostatic massage are, firstly, as a means of diagnosis in chronic gleet, and, secondly, in the treatment of all cases of sub-acute or chronic gleet in which the posterior urethra is involved, whether the prostate is the site of infection or not. The technique of prostatic massage is as follows :—

The bladder is filled with clear fluid; the patient is then placed in the knee-elbow position, holding the vessel containing the water with one hand under the meatus; each lobe is systematically massaged with the index finger through the rectal wall, firstly in the longitudinal direction and secondly by lateral pressure. This is repeated several times, firm but not too vigorous pressure being applied. Any discharge which is pressed into the urethra will be collected in the glass vessel or, later, on the passage of the fluid from the bladder. On the first occasion that this manœuvre is carried out the greatest

care should be exercised, as it is an extremely uncomfortable procedure and may often cause the patient to faint. Great force should never be used.

**Examination of the seminal vesicles.**—This examination should be carried out in all cases of chronic urethritis, as the inflamed vesicle is much more commonly the cause of chronic gleet than is generally recognised. The examination is made in exactly the same way as for the prostate.

**Bacteriological examination.**—An attempt should be made to demonstrate the presence of the gonococcus (see p. 104) in all stages of the disease. If the gonococcus is not present, examination for bacteria should be made, for although the majority of cases of urethritis are due to the gonococcus, it is well recognised that other bacteria, *e.g.*, *bacillus coli communis*, may produce a similar condition. The examination should be repeated frequently. Threads containing pus cells in the urine should always suggest infection. To complete the diagnosis of the absence of infection, if all the above tests give negative results, the patient should be allowed to take alcohol and again examined. More recently the complement fixation test has been adopted.

**The marriage test.**—A most important question for the surgeon to decide is, when is it permissible for the patient to marry? The patient should pass all the above-mentioned tests with negative results, and the examination should be repeated at intervals on at least three occasions. Provided that the results are negative, the presence of mucus at the meatus does not contra-indicate marriage.

*Treatment.*—**Prophylactic treatment.**—Prophylaxis commences before the act of coitus. Alcoholic intoxication plays such a large part in the incidence of the disease that it forms one of the strongest arguments against the excessive use of alcohol. Prolonged and repeated acts of coitus should be avoided. The use of a reliable condom is desirable. After coitus has taken place the urine should be passed, thus washing out the urethra and rendering the secretions acid, a condition harmful to the life of the gonococcus. The washing of the genitals with soap and water immediately after the act, paying especial care to the meatus, should be carried out. The instillation of 20 per cent. protargol jelly into the urethra, or irrigations of 1 in 2,000 potassium permanganate, best carried out by a doctor, is the most effective prophylactic measure that can be taken. These are best performed immediately after the act and must be used within twelve hours to be of service. The glans penis should be anointed with unguentum hydrarg. perchlor. (33 per cent.).

**General hygiene.**—(*a*) *Duty to others.*—In all cases the duty to others should be emphasised. The patient must be told that he is not to have intercourse with a woman until he has been pronounced cured by his doctor; he must not use the same towels, handkerchiefs, sponges, etc., as other people. Special precautions should be taken if using the same bath; a regular penile toilet should be carried out previously, the water being passed, irrigations used and the glans penis washed thoroughly; if others are using the same bath, they should do so first; after using the bath some antiseptic, such as carbolic acid or lysol, should be applied to it, but washing out thoroughly with fresh water is almost equally effective. The same remarks apply to the use of a common lavatory.

(*b*) *Duty to himself.*—(i.) Infection of the conjunctiva by the fingers should be avoided by washing the hands whenever they come in contact with infected materials. An antiseptic for use after hand-washing should be prescribed as an additional precaution.

(ii.) All forms of sexual excitement, the company of women, especially the young, immoral plays, and certain forms of pictures and erotic literature should be avoided.

**Treatment of acute gonorrhœa.**—(*a*) *General.—Rest*, as in all other inflammatory conditions, is essential for speedy recovery; the patient should go to bed for a period varying from ten days to three weeks, especially if posterior urethritis is present. Unfortunately, it is seldom possible to get a patient to do this, and in these circumstances all forms of exercise, prolonged walking, riding, bicycling, gymnastics, etc., are to be avoided. The scrotum and penis should be supported in a suspensory bandage, fitting so as not to compress the urethra in any part of its course; an athletic slip is a very useful garment for this purpose. Sexual intercourse is obviously forbidden.

Spicy, indigestible and acid foods, *e.g.*, tomatoes, asparagus, game, shell fish, strawberries, rhubarb, vinegar, mustard, pepper, pickles, curries, etc., should be avoided. A light diet and white meat are preferable in the acute stages of the disease. No alcoholic fluids should be taken; strong tea and coffee are to be avoided, also ginger beer. The drinks that may be taken include water, barley water, lemonade, milk, milk and soda, Contrexéville and other diuretic waters, cocoa and limejuice. Fluids should be taken in large quantities (from three to four quarts *per diem*). The numerous acts of micturition necessary to eliminate this amount during the day act by washing out the urethra and by diminishing the pain on micturition and irrigations. The only disadvantage is the liability to flatulence. Smoking is not harmful, but should not be carried to excess.

Of the drugs used, sandal-wood oil, given in capsules (dose 3—5 minims), every four hours, is the best. A number of substitutes, prepared so as to avoid the disagreeable effects of the pure oil, are on the market. *Ol. santali* is liable to set up gastric symptoms, and, if not carefully watched, renal pain, albuminuria, and even hæmaturia; it is of little value after the passing of the acute stages; it acts as a sedative as well as an antiseptic. Copaiba has a similar effect. Alkaline diuretics should be used. Other urinary antiseptics, such as urotropin, helmitol, salol, urodonal, can also be tried.

There is little evidence that vaccine-therapy is useful, except in cases of disseminated infection.

Purgation is necessary in the early stages. Bromide of camphor (0·75 grm.) in cachet is useful in the treatment of erections; irrigations of the rectum with warm water are also useful in this condition.

(*b*) *Local.*—(i.) *Anterior urethritis.*—No local treatment is necessary or desirable in the most acute forms of the disease, provided that the patient will go to bed, but as the disease commences to subside and the patient can stand this form of treatment, the use of irrigations is called for. The period at which these can be begun varies from the fifth to the tenth day; in the milder forms of the disease irrigation can be commenced on the first day, especially if the patient is walking about. The best drug to use for this purpose is potassium permanganate solution (1 in 8,000), the strength being gradually increased up to 1 in 2,000 until the discharge subsides. Potassium permanganate can be obtained in tablet form and should be dissolved in boiled or distilled water. Irrigations are best carried out by the surgeon by the "Janet method." In anterior urethritis the urethra should be irrigated three or four times a day; as the discharge disappears the number of irrigations may be diminished. A week or ten days after the irrigation treatment is begun a urethroscopic examination should be made and the presence of any inflamed follicles or sub-epithelial infiltrations noted. These may be

treated through the operating urethroscope or by dilatation with Kollmann's apparatus; this should be repeated weekly until there is an absence of discharge, no inflamed follicles or subepithelial infiltrations visible, and no pus cells in the centrifugalised deposit of the morning specimen of the urine. If the results of these investigations are negative, then the patient can be regarded as cured.

The period of treatment in acute anterior urethritis varies from two to six weeks according to the severity of the infection and the stage of the disease when the patient first comes for treatment. During the treatment the patient should be advised not to cover the meatus with pieces of cotton wool, but to collect the discharge and avoid soiling the clothing by the use of a bag which can be tied lightly round the penis.

(ii.) *Posterior urethritis.*—It is essential that the patient should be in bed. High fever is often present, thus indicating the need for the usual treatment of this condition; the use of hot hip baths and hot rectal douches is also useful. When infection of the posterior urethra occurs early in the course of the disease it is undesirable that posterior irrigations should be used; when, however, it comes on some weeks after the anterior urethritis has started, the infection is usually milder and the liability to complications not so marked; irrigations should then be employed. A weak solution of potassium permanganate acts best. The anterior urethra is first washed out until the washings come clear; posterior irrigations are then performed at least once in every twenty-four hours; every fifth day the prostate is gently massaged for one or two minutes. Fourteen days after the treatment has begun the disease should begin to subside.

**Treatment of chronic gonorrhœa.**—(*a*) *General.*—Rest in bed is no longer indicated; on the contrary, outdoor exercise, preferably in the country, and good feeding are desirable; violent exercise and sexual excitement, as well as alcohol, are still to be avoided. Drugs in the form of iron, quinine and strychnine (Easton's syrup) should be administered. It is during this stage that "gonophobia" is likely to set in, so that any form of treatment that will prevent the onset of this condition is to be strongly recommended. Vaccines may be of service and should be prepared from the flora present.

(*b*) *Local.*—(i.) *Anterior urethritis.*—It is necessary to find the localised inflammatory area which is responsible for the condition, spoken of by the patient as "gleet," before the treatment can be commenced. Injections should be kept up so long as there is general inflammation in the mucosa of the anterior urethra, but should be discontinued as soon as the lesions become localised. Plugged follicles should be treated by injections of silver nitrate (1—4 per cent.) or zinc sulphate. Urethroscopy will indicate the site of these infected follicles, each of which should be systematically destroyed, either by cauterisation with silver nitrate fused on the end of a probe, by an electric cautery, or by slitting up the gland sac with a knife. Massage of the urethra, into which a straight metal sound or a Kollmann's dilator has been introduced, is also an effective method of treatment. A repetition of this process every third or fourth day, combined with the single urethral irrigation of potassium permanganate, should be adopted. All submucous infiltrations are treated by dilatation and massage, either with straight bougies of increasing calibre or with Kollmann's dilators, straight instruments being used for the penile urethra and curved for the bulb.

(ii.) *Posterior urethritis.*—This condition is usually dealt with by injections of a strong solution of silver nitrate (1—10 per cent.) into the posterior

urethra following prostatic massage; it is introduced by means of an Ultzmann's syringe and allowed to remain in the urethra; the patient should be warned that he may have some pain after its introduction. The process should not be repeated more frequently than every fifth day. If this fails, posterior urethroscopy should be carried out and any lesion found treated by local applications. In all cases of posterior urethritis it is necessary to massage the prostate, even though there is no obvious infection of that gland.

*Chronic prostatitis* is dealt with by prostatic massage, which should be carried out every fifth to seventh day, the results obtained being regularly confirmed by bacteriological and microscopical examination of the secretion.

*Chronic vesiculitis* is also treated by massage. Special attention should be paid to these glands, as they are the commonest sites of infection in cases of chronic gleet.

In all those cases in which massage is performed the bladder should be first filled up with a weak solution of potassium permanganate, which should be passed subsequently so as to wash out any secretions which may have exuded into the urethra.

### Gonorrhœa in the Female.

The disease may start either in the urethra or in the cervix uteri; in the child the vulval orifice is a common site of infection.

An itching sensation in the region of the vulva with a white discharge is the commonest symptom.

It is unfortunate that the disease is not usually recognised in the early stages; it is usual for the infection to be fairly advanced before the patient comes for treatment.

In this condition, as in the male, a bacteriological investigation is essential for diagnosis. The common complications of the condition are endometritis, salpingitis and inflammation of Bartholin's glands.

It is through the female genital organs that primary gonococcal peritonitis arises, but it is a rare sequel.

*Treatment.*—The condition should be treated in the acute stages in a manner similar to that described in the treatment of the male; in the chronic conditions the urethra should also be similarly treated.

The cervix uteri usually demands more vigorous efforts, and it is extremely difficult to eradicate the disease from this site. Local applications of iodine, glycerin, argyrol, and silver nitrate are those most commonly in vogue, combined with the use of glycerin tampons in the vagina. The condition is extremely liable to recurrence, and it is almost impossible to say when the patient is cured, for, although bacteriological evidence may be negative for a considerable period, recurrences are very frequent.

Suppuration in Bartholin's glands should be treated by incision.

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